Editorials

Old Fire-Protection Truths Once More Emphasized

In fire-protection work it is not nearly so hard to know what to do as to get the people to do it. Many fundamentals have been established and constantly repeated demonstrations should prove their truth. Unfortunately—as in the human parallel—experience must be personal. The boy does not learn from his father's mistakes. Each city must go through its own ordeal by fire.

The disastrous conflagrations of March 21 and 22—noted elsewhere in this issue—ran true to form. In no one of the three cities laid waste could the inspecting engineer point out any lesson which had not already been emphasized in some previous holocaust; in each one of the three there were long known defects, the correction of which would have prevented or reduced the fire loss.

The three fires had more in common than the date of their occurrence. They were all in mixed residence and business districts; in no one was there any great congestion of buildings; in no one was a lack of water the main cause of the spread of the fire; in all there was a high to violent wind blowing which in each case carried brands onto near or far shingle roofs, thus contributing more than any other factor to the spread of the fire.

In cities of the age and size of Nashville and Augusta universal fireproof construction of the best type cannot be expected. It will only be an occasional building that will resist or even contain an inside fire discovered too late. But in the light of experience it is not too much to expect that the conflagration hazard—the danger of communicated fire—will be reduced by the easy precaution of preventing shingle roofs and open foundations. Frame walls are dangerous, of course, but they do not offer the easy lodgment of brands of the roof or the unobserved floor ignition of the open foundation.

All of this is an old story to the fire-protection man, as are the other facts brought out in the three Southern fires—such things as the loss of foreign engine efficiency due to non-uniform couplings, the uselessness of incomplete fireproofing, and the impediment of a cotton-bale clogged street. Possibly the coincidence of the lessons may be impressive and add emphasis to long established truths.

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Triple Expansion Still Ahead

Tests of a 30,000,000-gal. centrifugal water-works pumping unit in Montreal were reported in *Engineering News* of April 27, apparently showing a duty equal to that of the best triple-expansion pumping engine. Such an attainment was then supported by the reported data, but now the manufacturers of the unit state that they did not claim the attributed achievement; the trouble was that their computations of "duty" did not agree with the previously accepted practice of reporting water-works engine trials.

The reports received on tests of this unit showed a duty of 168.3 ft.-lb. per 1,000 lb. of steam (140° gage and 100° F. superheat). In accordance with recognized practice this corresponds to gross heat input. Deducting the heat rejected by the turbine as well as the somewhat meager data in this case permitted, the net duty seemed to be about 168 ft.-lb. per million B.t.u., which would have been a little better than the Bissells Point engine in St. Louis had done. For commercial reasons, it is stated, the makers reported a "duty" per 1,000 lb. of steam after crediting the unit with an amount of steam corresponding to the heat rejected, so that their figures are not what the term implies in accordance with standard practice. The reported figures, therefore, meant not the duty per 1,000 lb. of steam supplied under contract conditions, but an impossible hypothetical duty based on utilizing the entire heat in the steam. The heat used by the auxiliaries was retained in these figures.

The employment of such a basis and the quotation of such figures should be discouraged. No matter how plain is the warning of the true nature of the quoted duty, sooner or later the explanation will be lost. Then serious misinterpretation will result, as in this case. The confusion induced by such undesirable and unnecessary practices is just what it was aimed to eliminate by the American Society of Mechanical Engineers' universally accepted code for pumping-engine tests. That code should not be lightly departed from.

The proper figure for the Montreal unit now appears to be 134,000,000 ft.-lb. per million B.t.u.—although we have not had access to a log of the tests and are unable to further check the makers' statement. This figure is to be compared with 166,720,000 ft.-lb. for the Bissells Point engine. The triple-expansion reciprocating pump still leads the turbine-driven centrifugal.

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Nuisance Control for Health Instead of Sentiment

A large part of the efforts of many boards of health, local and state, is devoted—or sacrificed—to attempts to prevent nuisances having no relation to public health. To divert local boards from useless nuisance work and to guide or if need be force their energies against nuisances that have a vital relation to health and disease, the State Department of Health of New Jersey has just adopted, as a part of its new State Sanitary Code, a half dozen short, clear regulations, printed on another page of this issue.

The first regulation is a prohibition against maintaining "anything whatsoever which is a hazard or a danger to human health." This may sound as futile as it is broad, but subject to the unescapable rule of reasonableness by which all health regulations must be tested it may prove to be a powerful wide-ranging and far-reaching weapon of defense.

The next regulation is the most important one of the six. It prohibits maintaining a dangerously polluted water-supply, used for drinking or household purposes. It covers not only private wells but also all other sources of supply, including public water-supplies. If the city owns the water-works, the duty to furnish pure water is on it. If the works are privately owned the duty is both on the company to supply pure water and on the local board of health to see that the company does so.

The other regulations prohibit the maintenance of privies, and the disposal of human excrement and of sewage in such a way as to endanger water-supplies, and also prohibit various conditions which produce fly and mosquito larvæ.

All the regulations are framed with a view to enforcement throughout an entire state having a great diversity of population, industry and wealth. They constitute a minimum to which all parts of the state must conform but the law under which the State Sanitary Code was framed and will be enforced permits local boards of health to go as far beyond these minima as their judgment and courage may permit. This applies to the entire Sanitary Code now being framed, of which the nuisance sections already adopted are but a very small part.

These nuisance rules may seem woefully scanty to some but they go to the very heart of the matter so far as real health-protective work is concerned and are broad enough to accomplish marvels if intelligently and fearlessly enforced.

One of the Joys of Serving the Great Public

A committee of the New York Legislature, headed by Senator Thompson, of Middleport, has been for some months engaged in investigating various matters in connection with the New York subway construction. Some of the methods it has used in carrying on this investigation deserve severe criticism. A good illustration is the questions which were asked of Alfred Craven, Chief Engineer of the Public Service Commission, when he was placed upon the stand. With an honest search after the facts no one could find fault, but when the questions are asked in such a way as to by innuendo reflect upon the character of the witness, the investigation becomes no longer a judicial proceeding but a machine for perpetrating serious injustice.

The attacks of the committee upon Mr. Craven are particularly unfortunate because Mr. Craven has a record of 32 years of continuous service for the City of New York, and has not merely an unsullied record but has served in situations where his fidelity to his trust has been of enormous value to the city.

Some of the older members of the profession will recall the investigation in connection with the construction of the new Croton Aqueduct, as it was called when it was built in 1884. On some of the sections of that work the contractors instead of filling in with solid masonry behind the aqueduct lining as specifications required, left voids there large enough to take in empty cement barrels. Mr. Craven was the division engineer on the aqueduct work. He was one of the men on the engineering staff whose honesty was unquestioned and who was one of the chief reliances of the Fassett Investigating Committee in exposing the frauds. As a result of the revelations of this investigation, the late Abram Hewitt, then Mayor of New York, persuaded the Governor of the State to call an extra session of the legislature and passed a bill putting the old aqueduct commission under which the frauds had been perpetrated out of office. A new commission, appointed by Mayor Hewitt, was put in charge of the completion of the work and to make good the defective work, and Mr. Craven was one of the few engineers retained by the new commission. The contractors who had been responsible for the defective work were obliged to pump grout in back of the linings until all voids were filled. It was due to Mr. Craven's honesty and fidelity to his trust that the defective work was discovered in time to compel the contractors to make it good, and the city was saved at least $6,000,000.

There are other instances in Mr. Craven's long service to the city where his fidelity and integrity have been of the greatest value to the city. The engineering profession may properly resent gratuitous attacks upon the character of its eminent members.

Beginning Federal Expenditure for River Regulation

All the work thus far done by the Federal government on the rivers of the United States has been done ostensibly for the benefit of navigation. If the Humphreys bill now before the House of Representatives becomes a law, as now seems likely, it will mark the beginning of a new policy in river regulation. The Humphreys bill provides $45,000,000 for flood-control work on the lower Mississippi River, and $5,600,000 for flood control on the Sacramento. The bill does not directly appropriate these amounts, but it directs the Secretary of War to proceed with the work and appropriations to meet its cost will be provided in the Sundry Civil Appropriation bill next year and the years following.

The government has actually expended in past years a large amount of money to control floods in the Mississippi but the work has been done for navigation improvement. The Mississippi River Commission was created in 1879 and Congress has made appropriations for its work since that time of $85,680,000, of which about $29,000,000 has been spent on levee construction. The levee districts themselves have spent about $90,000,000 on levee work. It should be understood that the levee work is a necessity for the benefit of navigation as well as to protect the land back of the river from floods.

Engineers who have studied for years the problem of flood control on the lower Mississippi are agreed that the one effectual method of protecting from overflow the 20,000,000 acres of fertile bottom land along the course of the lower Mississippi is to establish a line of levees on each side of the river, from the head of the St. Francis basin on the north to the Gulf, and to make these levees high enough and strong enough to withstand the highest probable flood.

It is well known that the present levees are sufficient to withstand the high water of ordinary years. It was the record-breaking floods of 1912 and 1913 that aroused the Mississippi Valley to the importance of raising and strengthening these levees. The House Committee on Flood Protection, from the testimony of the engineers who appeared before it, conclude that the levees can be raised to the desired standard of height and sec-

tion in five years, with an expenditure of $6,000,000 a year from the Federal treasury supplemented by $2,000,000 a year from the levee districts benefited, in accordance with the terms of the Humphreys Act. In addition, a provision of $3,000,000 a year for bank revetment work is included, and the total annual appropriation was raised to $10,000,000 per annum in order that work might be planned for each season up to the full limit of the amount above named, and still leave a balance available in the annual appropriation sufficient for emergency work in case of a flood.

For many years the residents of the lower Mississippi River Valley have been appealing for a greater measure of government aid in the work of levee building. The greatest force behind the annual River and Harbor Appropriation bill for years has been the Mississippi Valley interests who urged appropriations for river improvements as a general policy in order that liberal appropriations might be given to the Mississippi River work. Evidently this repeated advocacy of Federal aid is at last to bear fruit.

The second part of the bill deals with flood control on the Sacramento River in California. It is probably little realized that the Sacramento has a flood volume exceeded by only three rivers in the United States, the Mississippi, the Ohio, and the Columbia. The maximum flow of the Sacramento is now estimated at 660,000 sec.-ft. Plans for the control of the Sacramento have been very thoroughly worked out jointly by state and Federal engineers. The work consists, in brief, of enlargement of the river channel and construction of four diverting weirs, at a total cost of a little less than $12,000,000. The State of California and the Federal Government have each contributed $400,000 already for this work. The appropriation above noted by the Federal Government supplies the remainder of its half. Besides this, a large amount has been and is to be expended by the land owners and municipalities to be benefited on levee construction and channel work. It is estimated that the total outlay by the property owners will eventually be in excess of $35,000,000, of which about half is still to be expended.

As might have been expected, the advocates of river control by reservoirs have been heard from, both in the discussions before the committee and on the floor of Congress. The Sacramento flood-control plan has been criticized as opposed to conservation, since it proposes to waste, through by-passes to the sea, flood waters which should be stored for beneficial use. At a hearing before the Flood Control Committee of the House, on Apr. 5, 1916, it was proposed that the floods of the Sacramento might be utilized "by conveying them in great flood water canals along the western slope of the Sierra Nevada Mountains to the south end of the San Joaquin Valley, and there utilizing them either through storage or by permitting them to soak into the ground so as to increase the subterranean water-supply."

The committee presents some interesting figures to test the practicability of this proposition. It assumes that such a canal would have to carry at least 200,000 sec.-ft., which is only a little more than one-third of the excess maximum floods of the Sacramento, which must be cared for outside of the river channel. Assuming a grade of 0.8 ft. per mile, such a canal would have to be 1,800 ft. wide and 20 ft. deep. If it took water from the Sacramento at Red Bluff and went no farther south than Los Palos, near Merced, a distance of perhaps 300 mi. on the contour line, it would, if run through level country, involve a total excavation of over 2,100,000,000 cu.yd. If only a small proportion of the excavation were in rock, the cost would exceed $700,000,000. The committee carried the computation still further, but this is ample to show the financial impossibility of such a scheme.

As to the proposition to store the Sacramento River floods in artificial reservoirs, the committee states that the engineers of the Army, the Reclamation Service, and the California State Engineering Department all agree that it is a physical impossibility to control the Sacramento River floods by storage reservoirs. In the discussion on Mississippi flood control on the floor of the House the advocates of reservoirs inquired why the floods could not be stored at their headwaters. The reply of Mr. Humphreys is worth quotation:

> We have gone very thoroughly into the proposition for reservoir control so far as the lower Mississippi River is concerned, and it has been the testimony of all the engineers who have examined it that it could not be done except by the expenditure of a sum so enormous that would stagger Congress to contemplate it.

The third section of the bill is especially noteworthy in that it lays down a general policy for the carrying on of surveys and investigations with reference to flood control on any river of the United States. According to this section, the Committee on Flood Control has authority to request the Board of Engineers for Rivers and Harbors to make examinations and reports on all works and projects relating to flood control in the same manner as for the Committee on Rivers and Harbors.

Why Increase the Civil Duties of the Army Engineers

The work done on the lower Mississippi under the provisions of the Humphreys bill noted in the preceding editorial is to be planned and carried out under direction of the Mississippi River Commission. The work done on the Sacramento is to be in charge of the California Débris Commission. It is the evident intent of Congress that all Federal work for flood control shall be carried on under direction of the Corps of Engineers. This action by Congress is entirely natural, for there is no other existing body of engineers to which it can turn with any confidence that the work will be done honestly and efficiently. On the other hand, it is obvious to every one that with the impending expansion of the army, the services of the engineer officers will be in urgent demand for military engineering work. The time is ripe, therefore, for the organization of a permanent body of civilian engineers for the government service in the field of river regulation. What is lacking is a thoroughly studied plan for the organization of such a body of engineers in such a manner as to insure high character and ability in the men composing it, freedom from partisan control and permanence of tenure.

There is every reason to believe that if the leading organizations in the engineering profession were to work out a practicable plan for such a civilian organization, it would have good chance of adoption by Congress. Unless and until this is done, however, Congress is pretty certain to continue its past policy of either utilizing the service of the Army Engineers or else leaving the heads of departments to secure engineering service as they think best.

Letters to the Editor

Co-operate, But to What End?

Sir—Under the head of "Coöperate, But to What End?" you discuss on page 812 of *Engineering News* for Apr. 27, 1916, the gathering of engineers at Chicago, Apr. 13 and 14. You say: "They came without tangible purpose, except to coöperate. They went apart with no more definite purpose: To coöperate, somehow, in the future. That is regrettable." I think that possibly you are not fully informed as to the real progress made.

To appreciate this we must bear in mind the mental attitude of the representatives of the various organizations of engineers. There has been and is not merely a desire to coöperate, but coupled with this a more or less indefinite fear that in entering upon such coöperation there may be involved some responsibility or danger to individual organizations. Because of this attitude of apprehension, it is necessary, first, to proceed with caution and to allay the fears of many otherwise well-informed men that somebody, somewhere or somehow, is trying to work out some scheme for ulterior purposes.

While a number of men who attended the conference had well-considered propositions, any one of which might have been adopted to mutual advantage, yet it did not seem wise to urge any one of these because of the too evident fear on the part of a respectable minority. They would have been confirmed in their fears had the majority of the members proceeded to take definite action along lines such as may be adopted after careful study. In the end more rapid progress undoubtedly can be made if for the first year or two the doubting Thomases are given ample time to consider all sides of the question.

It appears also that this fear had been intensified through the activity of some well-meaning friend who had taken pains to spread a rumor that the conference was called in the especial interest of one of the existing societies. While nothing of the kind was contemplated by any leader of the coöperative movement, yet there was enough erroneous information afloat to necessitate the use of considerable patience and tact.

A tangible result of this conference was to settle the first question asked in the call of Mar. 1, 1916; namely, "Is coöperation desirable, and is it practicable?" The answer given by the conference was strongly in the affirmative—that it is desirable and is practicable. The next step is to determine which of many lines is the most advisable to follow.

Farther along in your editorial you state: "By all means coöperate, but to what end? Let the end be apprehended clearly and made known!" This end is always in mind—namely, that of securing larger efficiency and economy in the activities of engineering organizations in order to bring about the largest service to the public through service to the members. More immediately, and leading to this end, are three important lines of work which were covered in the call and which should be kept always in view until substantial progress has been made. These three lines may be outlined as follows:

First, coöperation in securing wider diffusion of knowledge on engineering subjects. In this the results secured at Cleveland and elsewhere in publicity are instructive. This has led to better appreciation of the engineering profession and better service to the public. The excellent results already obtained and the possibilities of still larger achievement appeal to the members of nearly every organization. Through proper publicity the organization is strengthened, the interest of the members stimulated and the community benefited.

Second, better and more scientific study of employment of engineers, followed by the development, if possible, of a system which is more in accord with the intelligence of the engineering profession. Present conditions are not creditable to the assumed ability of engineers to deal with difficult matters. Many of the engineering associations have crudely conducted employment bureaus, some of which are doing good work; but the results are not such as to cause a feeling of pride of achievement.

The third and somewhat more remote end in view is a larger and better knowledge of legislative activity, not merely to promote legislation beneficial to engineers but to perform in a larger degree the duties of citizens, to anticipate needs and to turn the light of publicity upon schemes which the engineer from his knowledge of facts appreciates as unwise or harmful.

As stated by you, the opinion was expressed again and again to the effect that the individual engineer who turns to his technical society for counsel and help finds the society "static and supine, not to say torpid." This is a condition which need not exist and which can be corrected most effectively by frequent conferences and by full discussion of conditions and remedies. All agree with you, "There is logical basis for coöperation, if purpose backs the coöperation." Persons attending the conference surely believed that there is a purpose and that beneficial results are attainable.

I cannot agree with you that the Chicago conference failed to reach a diagnosis. While there may be a lack of agreement on details among persons who attended, yet on the part of many the diagnosis was fairly complete, and not one which it seemed wise to discuss at the present time, but rather to leave for a later meeting.

A volume could be written on the questions which you have raised, but the point I wish to emphasize is that the leaders of the movement for coöperation apparently are in agreement that large results can and will be accomplished through patience and tact rather than through trying immediately to urge the program of any one man or group of men. Let each and every organization be invited to consider these matters and to make suggestions.

It is probable that most of the plans presented by the different societies will be of a similar nature, and when finally adopted each organization will feel a proper interest in carrying out the program because of the fact

that it can take to itself a certain amount of credit for having initiated or suggested one or more of the details. For success, the movement must be from the ground up and not from any one man or group of men down or outward. The failure of so many attempts at coöperation has been largely because of neglect of this simple rule and because of the spread of the idea that the coöperation was initiated and sustained for the benefit of some one group or society rather than for the benefit of all.

F. H. NEWELL.

Urbana, Ill., May 3, 1916.

Co-operate, But in What Way?

Sir—In *Engineering News*, Apr. 27, there appeared a short article by Hugh J. Duffield, entitled "Should Engineering Societies Pass on Public Questions?" The case there involved shows the need of the sort of co-operation which was discussed editorially in the same issue under the title "Coöperate, But to What End?" What I have to remark also touches slightly on the letter of Albert J. Himes in the May 4 issue.

Mr. Duffield's communication deals primarily with the subject of engineering societies' passing upon public questions and thereby taking from the individual engineer some possible work and consequent remuneration and with it some of his standing. Mr. Duffield may be perfectly right in his criticism of the particular case in point; but if the society of which he speaks had been a real engineers' society and composed at least in its executive staff of men who were not only capable engineers technically, but also knew the primaries of professional ethics, such an examination as they made would not have been detrimental to the individual engineer connected with the work in question—unless that engineer had been doing inefficient work. Had he been doing inefficient work, it seems to me that the society would have been doing the engineering profession at large a kindness by putting the work upon an efficient basis. This would have been a case of the suffering of the individual for the good of the many.

This brings us to the editorial, "Coöperate, But to What End?" Societies that are voluntary organizations cannot coöperate to the fullest extent unless the individual members of such societies coöperate, and cannot coöperate in any case unless the executive officials of such societies coöperate. The line of demarcation between the individual effort and the society effort can seldom be sharply drawn, as one merges imperceptibly into the other.

> The lack of influence and power of the profession in the aggregate may be simply the resultant of the weakness and helplessness of each individual one of its members. If this is the case, then to strengthen the profession we must strengthen and help the individual.

This quotation from the editorial is only another way of saying what the writer has just said. Had the individuals making the examination of which Mr. Duffield speaks gone first to him or to whoever was originally in charge of this work and taken the matter up with him as a member of their own profession and as any regard for ethics would compel them to do, I cannot see how there would have been any friction in the matter. No engineer should be fearful of honest consultation.

I cannot understand Mr. Duffield's position when he states that "such a decision would have an influence not measured by the engineering ability of the investigators at all, but measured solely by the good or bad judgment of the men composing the committee." I cannot understand how the judgment, good or bad, of men composing a committee from an engineering society could help but be influenced by the engineering ability of those investigators. *One of the gravest faults of members of our profession in the past has been that many have tried to separate the engineer, so called, from the executive, so called.*

This has been done persistently, not only by engineers, but by those outside the profession. Many, many people carry the impression that an engineer is not and cannot be fitted to be in any manner an executive officer, that his judgment therefore as such cannot be relied upon and that he is to be believed or his opinion is to be asked only when his statements can be verified by the multiplication or division of figures or by the use of a right-line pen, a triangle or a pair of dividers.

"We engineers are in the grip of the times, and they are times of change," says the editorial. This is very true, and the closest kind of coöperation will not be too much to give the profession the standing that it should have as such. Without the standing the emoluments will not come. The engineering profession and the societies which represent it, including the civil, mechanical, electrical, mining and other groups, must not overlook the fact that it is not unethical nor unbusinesslike to boost for their own business; to throw back their shoulders and stoutly affirm that their profession and their work has a logical place in the scheme of things and that they are worthy of their hire. They must not accept longer the fallacy that to assist in the securing of good legislation or to assist in the killing of bad legislation for the profession is unethical. Until they work for themselves, no one will work for them. They must not be ashamed publicly to affirm that the members of their organization represent the men who can and are doing things; that their membership contains the best men in the world for any engineering project which mind can conceive; that the national engineering societies are the last word of authority on men and things engineering, whether it be construction, maintenance or operation.

> Complications of many different kinds arise to obstruct the activities of engineers, injure the good repute of the profession and make the individual's professional existence more precarious. . . . A leave-alone policy is a suicidal one. . . . It must take up each case and grapple with the difficulties.
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> They are the large matters, as legislative over-riding of the engineer's claim to existence and recognition, destruction of the business basis of technical work by introduction of dispensary methods, engineering negligence in large matters to the discredit of the profession, usurpation of important technical functions by administrative officers to the injury of the public's and the engineer's interests, and the like. Smaller matters of the same and other kinds number legion. All have been left untouched—yes, have been deliberately ignored—by the existing societies of engineers. And all of them are beyond the power of the individual engineer to combat unless he has the support of a broadly conceived coöperating body that makes his interests its own.

These evils have not been touched by the national engineering societies because those bodies are not fostering the coöperation of individuals. The broadly conceived coöperating body will have no greater success unless it somehow effectively aggregates all the thousands of little personal actions that are useful and possible.

THERON M. RIPLEY.

Watertown, N. Y., May 6, 1916.

Tests of Corrugated Culverts

Tests of the collapsing strength of corrugated-iron culverts have recently been carried on by George L. Fowler, of New York City, for the Armco Culvert Manufacturers Association. Preliminary tests were made under hydrostatic pressure, and these resulted in the development of a formula for collapsing strength similar to that employed in the design of corrugated boiler furnaces. Sand-box test results were interpreted to show that increase in depth of cover decreases the effect of surface loading and that, after an indeterminate depth, added cover did not add to the load on the pipe. Mr. Fowler has furnished a copy of his notes on these tests and all the following information is abstracted from them.

Hydrostatic Tests

For the hydrostatic tests, pipes of 12-, 24- and 48-in. diameters were used in a closed cylinder. The depths of corrugation were ½ and ¾ in.—both pitched 2⅔ in. Longitudinal seams were double riveted with a pitch of 2⅔ in.; circumferential seams were single riveted on a pitch of 8 in. All sheets and rivets were galvanized. Four thicknesses of metal were tested—16, 14, 12 and 10 gage. At each end of each culvert an internal angle flange was riveted; these were faced to 8 ft. apart and drilled to match the casing bolt holes. The internal diameters were measured with calipers reading to 0.02 in.

It was found, first, that the support of the casing at the ends did not extend in more than two diameters. The tabulated results were as follows:

HYDROSTATIC COLLAPSING PRESSURE OF CORRUGATED CULVERT PIPE

Diam. of Pipe, In.	Gage	Depth of Corrugation, In.	Collapsing Pressure, Lb. per Sq.In.	
12	16	½	225	
12	14	½	275	
12	12	½	420	
12	10	½	450	
12	16	¾	360	
12	14	¾	380	
12	12	¾	490	
12	10	¾	630	
24	16	½	52	
24	14	½	75	
24	12	½	130	
24	10	½	160	
24	16	¾	100	
24	14	¾	100	(125)
24	12	¾	180	
24	10	¾	320	
48	16	½	15	
48	14	½	20	
48	12	½	33	
48	10	½	58	
48	16	¾	29	
48	14	¾	39	
48	12	¾	45	
48	10	¾	70	

In interpreting the results Mr. Fowler considered the effect of diameter, thickness of metal and depth of corrugation. Strength of pipe was taken to vary with the strength of material and (within the range studied) depth of corrugation. The effect of diameter empirically entered (1) the exponent of a divisor of the thickness-corrugation product and (2) a correction factor of a simple formula first deduced. The final formual was:

$$P = \frac{5{,}960CT}{2^{\left(\frac{D-12}{12}\right)}}\left(1 - 0.4\log\frac{D}{12}\right)$$

where

P = Collapsing pressure in pounds per square inch;
C = Corrugation depth in inches;
T = Thickness of metal in inches;
D = Inside diameter in inches.

Mr. Fowler, however, simplified this (by inspection of the United States boiler-furnaces rules, and for diameters of 10 to 24 in., metal thickness of 0.0625 to 0.141 in., and working pressures of half the collapsing strength) to

$$\textit{Working pressure} = \frac{34{,}000CT}{D}$$

which can be used in design.

Sand-Bed Tests

For testing the collapsing strength under sand pressure, a box was made with one side movable to secure widths of up to 7 ft. The height was enough to allow 1 ft. of sand below a 48-in. pipe and 2 ft. above. Three 100-ton jacks gave the load, on three platens 24-in. wide and reaching the full length of the box. Diaphragm dynamometers were placed on top of the pipe and on two floating planks in the box side. The sand was kiln-dried and sharp.

Arching of the sand under pressure was evident. In a preliminary-test box it was found that the lateral thrust rose to a maximum under a shallow depth and remained practically constant; with a slightly yielding bottom the sand arched to relieve the bottom of load which was carried by frictional resistance of sand against the box sides.

In the main tests, it was found that when the platen was wider than the pipe the pressure was largely supported by the column of sand over the pipe and less by the more yielding sand beyond the pipe walls. Then the load imposed on the pipe was greater than as if considered uniformly distributed by the platen.

The results exhibited the conveyance and distribution of sand pressures, but were not considered sufficient to warrant developing a formula for calculating culvert pressures. For instance, it was seen that the top pressure on pipe decreases with a given load placed on increasing depths of sand, but the proportional relations were not disclosed. The lateral pressures were low and no definite ratio was established. The lateral pressure increased rapidly from the top down to a point determined by the angle of repose of the sand and then decreased.

In some of the tests the platens were replaced by 8-in. ties, 22 in. c. to c. supporting rails laid on 4 ft. 8½ in. gage. The loading jacks bore on the rails. With the broad platens the tests had been stopped when the top of the pipe deflected 1 in.; with the ties the deflection of the pipe was slight (average 0.14 in.) when the ties had sunk into the sand. (From this, incidentally, it appeared that a given area would support a greater weight upon a sand bed if concentrated than if divided into small separated units.) The gross burden on the ties was considerably greater than on the platens (237,800 lb. with 24-in. pipe), The recovery of pipe shape was complete on removal of the load.

It was concluded that under the heaviest load that can now be applied to railway ties by any existing locomotive or car, a 24-in. 14-gage pipe with ½ in. depth of corrugation, and under 24 in. cover of dry sand, cannot be deflected beyond its elastic properties of complete shape recovery. The 36- and 48-in. culverts are held to be unerushable under a cover equal to their own diameter. The weight of cover in a wide loose fill or bank is not so well supported as in a ditch and it was concluded that conditions of unusual severity might be induced which should be provided for by heavier metal.

Seventeen Millions Lost in Fires in One Day

By a remarkable coincidence the long period of freedom from large conflagrations in the United States was broken on Mar. 21 and 22 of this year by three destructive fires in widely separated sections of the South—at Augusta, Ga., at Paris, Tex., and at Nashville, Tenn. These fires started within 25 hr. of each other and the fire-fighting periods practically overlapped. Recently issued reports[1] by local fire-inspection bureaus show a striking similarity in the nature of the conflagrations and in the lessons to be learned therefrom. The main features of the fires may be briefly stated as follows, the data being separately given in the accompanying tabulation.

THREE CONFLAGRATIONS ON MAR. 21 AND 22, 1916

	Place		
	Paris, Tex.	Nashville, Tenn.	Augusta, Ga.
Fire started	Mar. 21, 5:30 p.m.	Mar. 22, 11:47 a.m.	Mar. 22, 6:20 p.m.
Length of fire	10 hr.	4 hr. 45 min.	10 hr. 40 min.
Area burned	264 acres	64 acres	160 acres
Buildings destroyed	1,440	648	682
Estimated loss	$11,000,000	$1,450,000	$4,250,000
Insurance loss	5,000,000	850,000	3,500,000

Paris, Tex.—The Paris fire started in a one-story frame, shingled-roof warehouse, in daylight on a hot, windy day. The flying brands soon communicated fire to adjacent shingle roofs in spite of a fairly good local fire department and much outside fire apparatus called in under its own power and by rail. On account of non-uniform couplings these latter were not of maximum efficiency. The fire was soon out of control and worked its way through the main residential and mercantile sections of the city. Of the destroyed buildings 704 were dwellings, 192 mercantile buildings, 522 small outhouses, and 22 public buildings; 73% had combustible roofs and 90% were of frame or iron-clad construction. The water supply did not have high enough pressure, but it is doubtful if this had very much effect except in local instances and in sprinklered buildings. Such sprinklered buildings where the water pressure was high enough were saved. Some reinforced-concrete buildings were in the line of the fire and the framework stood up admirably, but the lack of sufficient window protection resulted in interior gutting. An inspection of the reinforced-concrete construction also showed that in nearly every case insufficient protection had been provided for reinforcement in girders, for the steel was generally bare or its location clearly discernible though no water was applied to the members, showing the necessity of providing a protection of at least 2 in. of concrete for reinforcement in columns and girders. A very important fact is that shingle roofs help spread the fire.

Nashville, Tenn.—The Nashville fire started about noon in an unoccupied planing mill during a 44-mi. gale. In the immediate vicinity of the fire were mostly small frame buildings which soon caught and were destroyed in spite of the best efforts of the department. However, the important feature of the Nashville fire is that about an hour after it started the gale increased to 51 mi. per hr. and the burning shingles and flames of the nearly controlled fire were carried across an 1,800-ft. clear space and ignited other shingle-roof buildings in the center of a highly valued residence section in East Nashville. Here the speed of the fire was remarkably rapid, due first to the very high wind prevailing, and, second, to the light frame, open foundations and shingle roofs of the residence section. The fire was fought entirely by the local fire department, and the water service was apparently sufficient. The tabulation of the buildings burned is as follows: Frame with shingles, 159; frame with fire-resisting roofs, 180; brick with shingles, 1; brick with fire-resisting roofs, 79; frame, small buildings, 229.

Augusta, Ga.—The Augusta, Ga., fire broke out at 6:20 p.m., in a dry-goods store, which had been closed about 6 p.m. The wind was about 22 to 26 mi. per hr. and decreased during the progress of the fire. The building in which the fire started was a brick-wall, wooden-frame structure, five stories high, and known locally as a fire trap. The fire soon got beyond the control of the local company and companies from adjacent cities were called in. Great trouble was had in getting the foreign engines to work on account of nonuniformity of hose connections. The fire burned through business and residential sections, some of them the best in town. The residential section was mostly frame with shingle roofs, the business of brick mostly with metal roofs, but with many very old buildings. The water-supply was inadequate. Of the buildings burned 113 were brick, 569 frame; of these 541 were dwellings, 100 mercantile establishments, and 41 miscellaneous. The fire was undoubtedly carried by shingle roofs and by the frame structures. The fire fighting was obstructed by the great amount of cotton stored in the streets, a common practice in many Southern cities, which not only prevented the engines from getting to work but also helped the spread of the fire.

[1] Paris, Tex.; report of the National Fire Protection Association, 87 Milk St., Boston, Mass., and report of the National Board of Fire Underwriters, 76 William St., New York. Nashville, Tenn.; report of the National Fire Protection Association. Augusta, Ga.; report of the Southeastern Underwriters Association, Atlanta, Ga.

Gravel Roads in Illinois

For county work in gravel-road construction in Kane County, Illinois, the county supervisors have their own machinery. This includes a 40-hp. gasoline engine to operate a 3½-ton road grader (with 12-ft. blade), a portable screening and crushing plant, and a tank wagon. There is also a 5-ton motor-truck with 5-ton trailer, which distribute the road material and are used to move the crushing and screening plant from place to place.

In distributing the gravel all hauling is done over the gravel already laid, so that the motor truck operates as a roller. The material is placed in two courses, in order to get a thorough rolling. The truck wheels have steel tires, 10 in. wide on the front and 21 in. on the rear wheels. The loaded truck weighs about 14 tons, of which the rear wheels carry 70%. The truck and trailer stand under the storage bin to load.

When distributing, the bottom-dump trailer is first unloaded, this being done while it is in motion, in order to spread the material. It is then uncoupled and the rear-dump truck unloaded by tilting, after which it is turned around and coupled to the other end of the trailer for the return trip.

The portable screening and crushing plant has an output capacity of 200 cu.yd. per day. It consists of a rotary screen, a crusher and a 15-yd. storage bin, together

with a bucket elevator and two belt conveyors. To keep the height within limits convenient for transportation, the screen is mounted separately, instead of being carried above the bin. This plant was built by the Stephens-Adamson Manufacturing Co., Aurora, Ill.

The gravel from the pit is moved by scrapers and dumped into a hopper over the lower end of a belt conveyor that elevates it to the screen. From the screen the product of ⅛- to 1½-in. size is fed by a chute to the boot of a bucket elevator that delivers it to the storage bin. The oversize is delivered to the crusher beneath, the product of which (crusher-run) goes to the elevator and bin. Material finer than ⅛ in. is delivered to a second belt conveyor and discharged upon a waste pile.

For moving the plant, the motor truck is run under the bin, which is lowered upon it, the supports and other parts being placed within the body. The screen is loaded upon a wagon, the crusher has its own wheeled frame, and the various accessory parts are placed in the trailer. The motor truck hauls the trailer and tank wagon, while the tractor hauls the crusher and screen. G. N. Lamb, of St. Charles, Ill., is County Superintendent of Highways.

Columbia Engineering Alumni Dinner to Professor Burr

The alumni of the schools of engineering of Columbia University, numbering over 100, gave a dinner at the Waldorf Astoria in New York on Apr. 26, in honor of Prof. William H. Burr, who after 36 years' service as a teacher of engineering is to retire from the chair of civil engineering at Columbia at the end of the college year. Among the after-dinner speakers were President Nicholas Murray Butler and Public Service Commissioner Henry W. Hodge. Mr. Hodge was a student under Professor Burr and later began his work in bridge engineering as an assistant to Professor Burr in his private practice. The following extracts from Professor Burr's address are a valuable contribution to the discussion on engineering education:

I was trained as a student to the historic view of civil engineering as being the foundation of all engineering not military. In my student days the great specialties of the present time had scarcely been recognized, except that mechanical engineering had been formulated, but had not become full-fledged. I have adhered to that historic and fundamental view. Civil engineering is not a specialty, and the educational training required in qualifying for the practice of the profession should include the fundamentals of both mechanical and electrical engineering.

It is interesting to contrast some conditions of the present professional service to those which existed forty years ago or more. As a student in the most prominent and effective engineering school in this country at that time, in all my four years of study I do not recall a single practical problem of structural design given by any member of the faculty, nor was there any express or formal opportunity for a student to confer with an instructor regarding his work except as he might seize it for a few minutes at the end of a recitation or lecture. Assignments in textbooks or lecture notes were given daily for preparation before the next exercise, and the student was expected to prepare himself for a drastic test, and not one escaped in that daily routine.

At the present time, on the contrary, from the beginning until the end of every day, he has constantly recurring opportunities to consult with instructors at almost any hour; and for considerable portions of the day he is expected to work out his problems and other design exercises under the direct aid and explanation of an instructor.

While the present procedure is certainly more merciful and in large degree helpful, I am by no means certain that the advantages are all in the modern practice. The old plan, drastic and unfeeling as it was, certainly bred men, men of self-reliance, of capacity for initiative and with a resolution and vigor in professional duties that are not too frequently in evidence at the present time.

I have heard a high administrative officer of one of our larger American universities say that he desired to have instruction work so administered that a student might call at any time whatever upon an instructor for any aid which he might desire. It is probably needless to say that that particular administrative officer had never had a day's experience in instruction work in his life. Such a system of day-nursing demoralizes and weakens the student's fiber, and a more perfect system of destroying initiative and self-reliance on the part of a young man cannot easily be devised.

SPECIALIZATION HAS RUN RIOT

There is no doubt of the fact that on the whole the present system of engineering study is in effectiveness a substantial improvement upon that which prevailed thirty or forty years ago, but we have by no means got to that point where we can afford to ignore the lessons of the past. Specialization has run riot in engineering education and gone to seed in such a way as to give the special graduates a maximum capacity of adaptation to a narrow range of work with a minimum of educational effect. If it is the intention to make graduates of engineering schools educated men as well as adapted to their field of professional work, it will be necessary to restrict materially the specialization now existing. The true aim of an engineering school should be to give its graduates not only an adaptation to the conditions of work in their future professional activity, but also to make them broadly educated men and give a due quality of scholarship to their service. In other words, to develop and equip them for well-rounded and general competency rather than narrow facility. The former will make by far the strongest professional man in his life work, and that should govern.

THE IMPORTANCE OF TEACHING THEORY

I have always emphasized the teaching of engineering theory, and it passes my understanding how any instructor in a professional engineering school can attain to even the poorest form of engineering instruction without not only teaching engineering theory, but giving it first place in his work, and I say this deliberately in view of the fact that I have been an active practicing engineer from the time of my graduation to the present day, and I expect to remain so for the remainder of my life.

If there is any way of making an effective professional engineer without founding his educational training or knowledge on engineering science, I admit openly that I do not know what it is; and if there is any other method of conveying a knowledge of that science than by teaching engineering theory, I have never yet discovered it.

The marked advances made in the modern engineering schools stand obviously among the great achievements of university work, and there is little else but praise to be given to those who are conducting them. There are, however, some respects in which the contrast between the older schools and those now existing is not altogether in favor of present practices. Among the chief aims of every professionel school ought to be attainment by students of initiative, self-reliance, decisive and resolute treatment of professional work. The great numbers of students now collected in these schools and the necessity of systematic and effective administration have caused some serious misdirected efforts. . . .

The university is not a factory, as President Butler has repeatedly said in his annual reports. It is not the province of the university to force in a machine-like way its students through grooves and dies, or to submit them to the standardizing operations of educational lathes and planers so as to produce interchangeable parts of machines rather than educate and develop individuals each with his own creative power brought to its best effective condition.

THE PASSION FOR CHANGE

Again there has gradually crept into the educational life of engineering schools what I think may be properly called, for lack of something better at least, the vaudeville, a kind of raw, unregulated, but well-meaning desire to change abruptly about everything which has been found effective in long experience by a more or less chaotic and unreasoned effort to gain improvement, without realizing that a good deal of the best may be wrecked in the procedure.

It is probably unnecessary for me to say that all the solicitations of the vaudeville have not attracted me. There is nothing more effective in the extension and development of an engineering school than excellent things quietly and well done; and the more work of that sort performed the greater and more enduring will be the service rendered to the profession.

Bear Valley Multiple-Arch Dam Overflows for First Time

The new Bear Valley dam, one of the largest of the multiple-arch concrete type, overflowed for the first time on Jan. 21, 1916, as shown in the accompanying view from a photograph taken on that day. This dam, located in the San Bernardino Mountains of California, was described in *Engineering News,* Dec. 25, 1913, p. 1284. It was built upstream of the famous Bear Valley arch dam, which for many years held the record for slenderness of

WATER GOING OVER BEAR VALLEY DAM ON JAN. 21, 1916

section. It is of interest to quote the following extract from the article mentioned:

> It was proposed to erect a dam to a height of 65 ft. above the base datum zero of the old dam, giving a capacity in millions of gallons of 17,000, but the large runoff of the winter of 1909 showed that there would have been lost a considerable quantity of water at that height, so it was finally determined to run it up to the 70-ft. contour, giving it a capacity of 21,000 millions of gallons and this in the completed plans was raised finally to the 72-ft. contour, giving a capacity of 22,880 millions of gallons, the new datum giving a crest elevation of 6,746 ft. above sea level.

The photograph was furnished by Herbert Garstin, President of the Bear Valley Mutual Water Co.

Health Nuisances Prohibited in New Jersey

Nuisances having a relatively direct effect upon health are dealt with in a half dozen short regulations in the initial portion of the State Sanitary Code just adopted by the New Jersey Department of Health. The regulations are as follows:

> 1. No person or private or municipal corporation shall maintain or permit to be maintained anything whatsoever which is a hazard or a danger to human health.
>
> 2. No person or private or municipal corporation shall maintain any well, or other supply of water used for drinking or household purposes, which is polluted in any manner that may render such water injurious to health, or which is so situated or constructed that it may become so polluted.
>
> 3. No person or private or municipal corporation shall maintain, use or permit to be used, any privy or other receptacle for human excrement, unless such privy or other receptacle is so constructed and maintained that flies cannot gain access to the excremental matter contained therein, and unless such excremental matter shall at all times be prevented from flowing over or upon the surface of the ground. Every privy or other receptacle for human excrement located within 100 ft. of any stream, the waters of which are used for drinking or domestic purposes, shall be provided with a water-tight vault.
>
> 4. No person or private or municipal corporation shall permit any human excrement, or material containing human excrement, to remain on the surface of the ground nor shall such excremental matter or material containing such excremental matter be buried or otherwise disposed of within 100 ft. of any stream, well, lake, spring or other source of water used for drinking or domestic purposes; nor shall any such material be deposited in any place where it is likely to gain access to such waters. Provided, however, that this regulation shall not apply to effluents from sewage-disposal plants which have been, or hereafter may be, approved by the State Department of Health.
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> 5. No person or private or municipal corporation shall maintain, or permit to be maintained, any accumulation of decomposing animal or vegetable matter in which fly larvæ exist on any premises upon which is located any hotel, boarding house, lodging house, restaurant, or any other establishment in which foods intended for sale or distribution are prepared, handled or sold, or at any point on any other premises within 250 ft. of any dwelling occupied by another.
>
> 6. No person or private or municipal corporation shall maintain or permit to be maintained, any pool, pond, ditch, stream or other body of water or any cistern, privy vault, cesspool, rain barrel or other receptacle containing water, in which mosquito larvæ exist.
>
> 7. These regulations shall take effect on June 1, 1916.

The State Sanitary Code is being framed in accordance with a legislative enactment of 1915. The Code will supersede all local health board rules and ordinances throughout the State but local boards may adopt other and stricter rules not inconsistent with the Code. It is the duty of the State Department of Health to see that not only the State Sanitary Code but the sanitary and health laws of the State as well are enforced. In case of local non-enforcement, the Department has authority to do the necessary work and recover the cost from the municipality in an action for debt.

Detroit Sewage Disposal from International Viewpoint

A $6,000,000 sewage-treatment plant, consisting of sedimentation and Imhoff tanks, followed by disinfection, would be the most economical method of meeting local needs and protecting both American and Canadian interests, according to a report just made by Clarence W. Hubbell, Consulting Engineer of Detroit, to George H. Fenkell, Commissioner of Public Works of that city.

Mr. Hubbell was engaged late in 1914 to review the data and conclusions of the International Joint Commission as to the protection of Canadian waters from Detroit sewage. He was also asked by Mr. Fenkell to consider the extent to which the "sewage of Detroit pollutes American waters so as to render them unfit as a source of raw water for filtration purposes." A third line of inquiry referred to Mr. Hubbell involved the means, if any, which should be used by Detroit to treat its sewage and the expense which would be justifiable for that purpose.

After a general review of the report to the International Joint Commission, as related to Detroit conditions, Mr. Hubbell says:

> It therefore follows that preventive or remedial measures required with reference to pollution crossing the boundary line from either side should logically be limited to such sewage treatment as may be necessary to prevent an undue burden being placed on any water-purification plant having an intake suitably located in the best raw water obtainable within a reasonable distance from the plant. In our [my] judgment such results can best be insured for all future conditions likely to occur, by sterilization of all sewage discharged from vessels, and by eventually collecting all urban sanitary sewage at convenient points where it may be treated either by means of fine screens or settling tanks, followed by sterilization.
>
> Detroit should anticipate such a system for other reasons than that of preventing pollution from crossing the boundary line.

Taking up next the relation of the sewage of Detroit to the water-supplies of nearby American cities, Mr. Hubbell first says that it is difficult to distinguish between pollution from either side of the boundary line. There is a zone "of grossly polluted water" along the whole American shore of the river between Lake St. Clair and Lake Erie. The zone varies in width and the degree of pollution decreases from the shore outward. Within this polluted zone the water is "unfit as a source of raw water for filtration purposes."

The water-supplies of Michigan most affected are those of Ford, Wyandotte, Trenton, and Monroe, but the Detroit sewage does not render the raw water "drawn for the supply of any of these cities" unsuitable for filtration purposes. In the cases of Ford and Wyandotte, water suitable for filtration can be obtained through an intake extending about 3,000 ft. into the river. Trenton is worse off, for it "cannot obtain a suitable supply within reasonable distance or cost" as matters now stand, but it "could do so were Detroit sewage treated as recommended in this report."

The sewage of Detroit does not reach the Detroit waterworks intake crib under ordinary conditions, but strong easterly winds sometimes cause a back flow in the river, especially if they coincide with ice gorges in the St. Clair River. Such conditions are likely to occur once in four or five years and to endanger the supply. The probability of this backflow, combined with increasing unpreventable pollution, surface wash, and storm-water sewage will probably justify the construction of a new waterworks intake further removed from the influence of shore pollution some time in the future, even if Detroit does build sewage-treatment works.

As to the most desirable method and cost of sewage treatment for Detroit, Mr. Hubbell points out first that owing to the large amount of dilution available in the Detroit River, oxidation methods are not required for Detroit sewage. It is desirable, however, to remove oil, grease, feces and other floating matter from the sewage. Most important of all is the removal of disease germs. Elaborating on this point, Mr. Hubbell says:

> Studies indicate that a removal of some 90 to 95% of the total bacteria in the sewage will be necessary to reduce the pollution in the river below Detroit to a standard 500 B. coli per 100 c.c. for average conditions. This can best be done by the use of a disinfectant, such as hypochlorite of lime.

After considering various methods of sewage treatment, Mr. Hubbell says the choice lies between (1) Imhoff tanks with disinfection located at Fort Wayne and Fairview on the river front, and a future plant on Connor's Creek, and (2) five plants in which fine screening would be combined with disinfection. Under the first alternative the sludge would be disposed of by filling in lowlands or by incineration, or sold as a fertilizer after drying. Under the second plan the screenings would be burned.

Although sedimentation and screening would be the most expensive of the two plans in first cost, Mr. Hubbell concludes that this plan is the most desirable one, as it would also be the most economical, taking into account all of the annual charges. He estimates that the first cost of Imhoff tanks and disinfection for a population of 950,000, together with necessary collecting sewers, would be $6,091,000. The annual charges, including interest at 4½%, amortization (rate unspecified), operating cost and maintenance are estimated at $517,430, or 54.5c. per capita. These estimates do not include the future plant on Connor's Creek.

Finally, Mr. Hubbell says that "it is difficult to formulate an answer in terms of money alone" to the question, "What expense would be justified for sewage treatment?" He believes, however, that considering the international features of the problem, the benefits to the water-supplies of Detroit and other cities on the American side and the various amenities of the case that an expenditure of $6,000,000 for construction would be justified.

Mr. Hubbell's report was transmitted to the Mayor and Council of Detroit by Commissioner Fenkell on May 9, without recommendations, but accompanied by a review of the methods and cost of sewage treatment as adopted or proposed by a number of other large American cities.

Canadian Power Development Under Arbitration

The Ontario Government has received a communication from the Government of the United States in reference to the proposed development of hydro-electric power at Chippewa Creek. It points out that American citizens are entitled to the use of half the water of the rapids of the Niagara River and that "it can hardly be expected that the Government of the United States will concede that this right may be curtailed by the diversion of the waters above the Falls on the Canadian side in such a way that they will not be returned to the stream except below the Gorge." The note further suggests that in case the views of the American and Canadian Governments are not in accord on the subject the matter might be regarded as an appropriate one to be referred to the International Joint Commission.

Hon. I. B. Lucas, Attorney General of Ontario and a member of the provincial Hydro-Electric Commission, when interviewed on the subject stated that the Ontario Government had always anticipated submitting the plans of the proposed work to the International Joint Commission. Before the Government had any knowledge of a dispatch from the American Government it had authorized the Hydro-Electric Commission to prepare maps and plans to submit to the Joint Commission for approval in pursuance of the provisions of the treaty. It may have been assumed that this consent would be given largely as a matter of form, but the dispatch from the American Government shows that it will be a matter for some adjustment.

News of the Engineering World

Elmer Lawrence Corthell

Elmer L. Corthell, President of the American Society of Civil Engineers, died at Albany, N. Y., on May 16, 1916, at the age of 76 years. Mr. Corthell had for some time been confined to his bed at his summer home in Massachusetts, but his sickness took a turn for the worse during the past week and he was brought to the hospital in Albany, where he died. A full biography and portrait of Mr. Corthell was published in *Engineering News* of Feb. 3, 1916, as one of the biographies of the current presidents of the four national engineering societies. It is not necessary, therefore, in this place to do more than note the history of his professional life.

After service in the Rhode Island artillery in the Civil War, Mr. Corthell reëntered Brown University, where he had been at the breaking out of the war, and graduating therefrom in 1867, started at that time a continuous service in the profession of engineering. This service comprised railway work in the Middle West; a long and arduous experience on the Mississippi jetties; bridge design and construction, mostly on the Mississippi, Missouri and Ohio Rivers; and finally during the later years of his life an international experience in harbor construction, mainly in South America.

Mr. Corthell's professional honors have been many, not the least of which was the presidency of the great national society, which he held at the time of his death. Only one other president of the American Society of Civil Engineers has died in office, Mr. Ashbel Welch, who died Sept. 25, 1882. Clemens Herschel is senior vice-president of the American Society of Civil Engineers and will succeed to the office of president.

Fire-Protection Convention

The National Fire Protection Association at its 20th annual meeting, held in Chicago May 9 to 11, passed a series of resolutions including the following recommendations: The adoption by municipalities of the building code approved by the Association and of ordinances for systematic inspection of buildings, the passage of state laws for the fire-marshall system, minimum requirements for hospitals and other public institutions, and establishing personal responsibility for damage due to fires caused by carelessness. The more general use of sprinkler and fire-wall protection was advocated. Another resolution advocated inspection by the engineers of the Association of municipal matters relating to fire prevention and protection; these would include water supply, fire equipment, fire alarm system, building code, etc.

The possibility of coöperation by neighboring cities for mutual aid in case of fire was discussed, and it was shown that in many cases the use of individual types of couplings and fittings continues to be a bar to such outside assistance.

The fire protection of high-value districts was a special topic of discussion. Albert Blauvelt (Chicago) advocated the special high-pressure system, and suggested that in promoting the use of such protection more emphasis should be laid on its economic value. H. W. Forster (Philadelphia) spoke very strongly in favor of the automatic sprinkler system, which is adaptable for small as well as large cities. He considered that in most cases the available pressure is ample, without a special high-pressure system. In many cities it is 100 to 150 lb., and Omaha has even 175 lb. for all purposes. In most cities, also, there is willingness to furnish water for fire purposes at little or no cost, the value of the use of such water in preventing conflagration and loss being now recognized.

Greater coöperation of the engineer with the state legislator, the alderman and other political forces was urged by Herman L. Ekern (Wisconsin) as a means of introducing better protection for high-value districts. The engineer's reports alone accomplish nothing, but what is needed is the legislator or alderman who has been educated by contact with the engineer so that he understands what the situation is and what the engineer's report really means to the community.

Specifications for the construction of an office building with the highest practical type of fire resistance were submitted by the Committee on Fire Resistive Construction. Suggestions for the elimination and protection of defects which constitute fire hazards were discussed in another report. Such defects include hollow floors (wood) without firestops, stairway openings and elevator shafts, and floor openings for belting and machinery.

Outside stairs were advocated strongly by the Committee on Safety to Life, and its recommendations were adopted without discussion, although formerly there has been strong opposition to endorsing the use of such stairs. This committee also called attention to the laws of New York and Wisconsin which base the allowable number of occupants for any floor upon the exit capacity. The suggestions for protection of buildings against lightning, submitted by the Committee on Signaling Systems, led to protracted discussion.

Two subjects of sociological character were presented relative to the protection of children and young people in factories and schools. Miss Mary E. McDowell advocated complusory fire-drill. She referred to disasters in which panic was a leading cause, and laid stress upon the economic loss due to injuries and sickness among those who are not able to support themselves except by their daily work. Even in a fireproof building with good fire protection, a slight fire or other cause of panic on an upper floor may result in a terrible disaster.

The other matter was a discussion on safeguarding children from fire. This covered three specific points: The planning of school buildings with a view to safety, the use of fire escapes and fire drills, and the care of school buildings.

Tests of pipe elbows to determine the friction loss indicated that the loss of standard elbows is 50 to 100% greater than that of long-turn screw-end elbows, and it is proposed to design new standards of the latter

type. The Committee on Explosives and Combustibles submitted amendments to present regulations relative to containers, fuel oil, internal combustion engines, and acetylene generators for lighting.

The meeting was held in the auditorium of the Insurance Exchange Building. The attendance was large and the discussions were active. The officers for 1916-17 are as follows: President, Charles E. Meek, New York, N. Y.; Vice-Presidents, Louis Wiederhold, Jr., Philadelphia, Pa., and D. Everett Waid, New York, N. Y.; Secretary and Treasurer, Franklin H. Wentworth, Boston, Mass.

Elephant Butte Dam Completed

The Elephant Butte Dam, located on the Rio Grande about 14 mi. west of Engle, N. M., and the main structure in the Rio Grande project of the United States Reclamation Service, was officially dedicated on May 13, 1916. The dam is of rubble concrete with a gravity section and straight plan. It is 1,200 ft. long at El. 4,414, the roadway surface, 203.5 ft. high above the original river surface and 304.5 ft. from deepest excavation to top of parapet wall. The maximum width at base is 215 ft. and the roadway top is 16 ft. The masonry content is 550,000 cu.yd. A reservoir was created 45 mi. long and with 42,000 acre area, containing when full 115,098 million cubic feet. Numerous articles describing the design and construction of the dam have appeared in *Engineering News*, notably in the issues of Jan. 16, 1913, p. 120; June 19, 1913, p. 1270; Jan. 14, 1915, p. 51; Sept. 30, 1915, p. 645; Oct. 7, 1915, p. 696.

John Edson Sweet

John Edson Sweet, Hon. M. Am. Soc. M. E., one of the best known and most affectionately regarded men in the entire engineering profession, died suddenly at his home in Syracuse on May 8. He was born in Pompey, N. Y., in 1832, and was there educated in the district schools. He early exhibited his mechanical ingenuity and in 1850 was apprenticed to a carpenter and joiner. After about a year he entered the office of a local architect, where his work attracted more than local attention. From 1862-4 he was a draftsman for Hazeltine, Lake & Co., and the Patent Nut & Bolt Co., in Birmingham, England. On his return to America he was a designer for

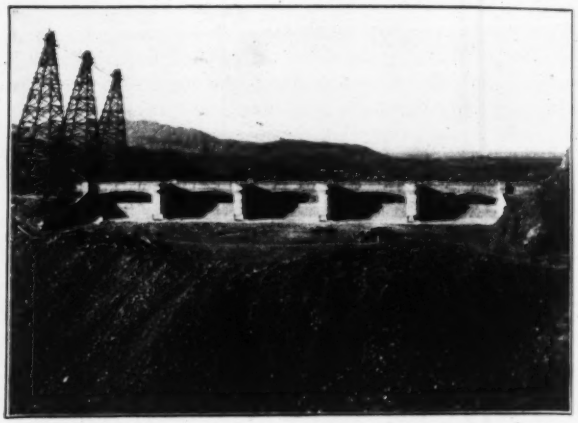


FIG. 2. SPILLWAY ON ELEPHANT BUTTE DAM

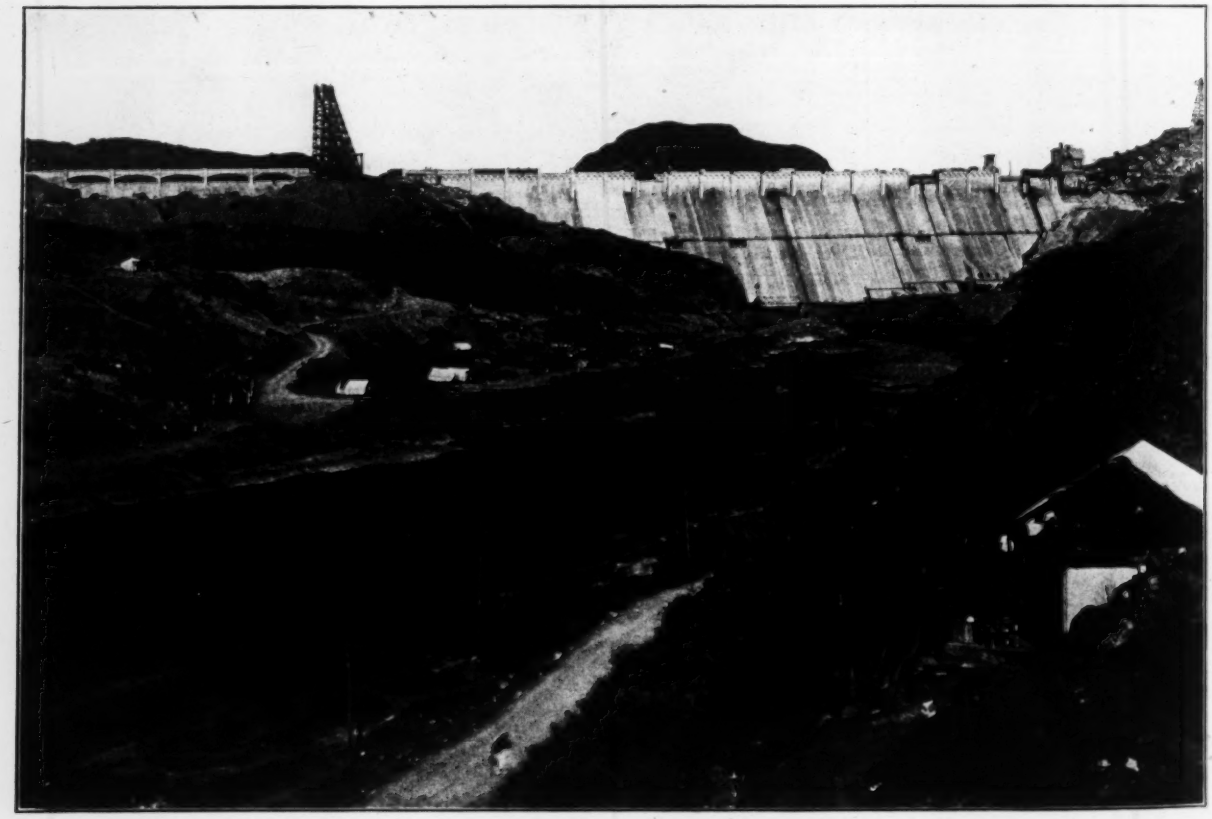


FIG. 1. DOWNSTREAM FACE OF ELEPHANT BUTTE DAM NEAR COMPLETION

Sweet, Barnes & Co., of Syracuse. About this time he devised a typesetting machine, which was exhibited at the Paris Exposition in 1867. From 1871-3 he was a bridge builder for Howard Soule of Syracuse, and in these years built the first of the famous "straight-line" steam engines.

In 1873 he was called as professor of practical mechanics in Sibley College, of Cornell University, and here he laid the basis of his world-wide reputation as an engineer, and in spite of only six years of teaching made those notable friendships which clung to him with his title "Professor" to the end of his life.

He left Cornell to take up the commercial development of his Straight-Line engines—the success of which has become a matter of record. The shops of the Straight-Line Engine Co., of which concern he became president in 1880, became a notable institution because of the quality of its work and the spirit which pervaded it. Over its entrance was written "Visitors Always Welcome."

Professor Sweet was one of the leaders in the founding of the American Society of Mechanical Engineers, and its third president, in 1883. From 1899 to 1901 he was president of the Engine Builders' Association of the United States. He was always active in local technical affairs, having been, for example, president of the Syracuse Technology Club and of the Syracuse Metal Trades Association. He had served as mechanical expert for the U. S. Navy Department and in 1893 was one of the jurors at the Chicago Exposition. In 1906 he was president of the John Fritz Medal Association. Syracuse University conferred on him the honorary degree of Doctor of Engineering.

From his earliest days in the Syracuse architect's office he had been a facile writer and his contributions to technical publications were numerous. In 1906 he published the volume "Things That Are Unusually Wrong"—discussing features of machine design.

Cloud Clifford Conkling

Cloud Clifford Conkling, M. Am. Soc. C. E., Chief Engineer of the Steel Sheet Piling Department of the Lackawanna Steel Co., died on May 8, at his home in Buffalo, N. Y. He was born in Rensselaerville, N. Y., in 1862, and attended the public schools of Scranton, Penn. He continued his studies, including civil and mining engineering, and was first employed, in 1881, as rodman on the Erie & Wyoming R.R. and in a similar position during the following year on a water-supply survey of the Ramapo Valley, New York.

In 1882 and 1883 he also took a special course of study at Williston Seminary, Easthampton, Mass., and the next two years was draftsman and transitman in the city engineering office of Scranton. He was also engaged on a railroad survey in New Jersey under J. H. Rittenhouse. He served for 12 years in the National Guard of the State of Pennsylvania, retiring as Sergeant Major of the 13th Regiment.

In 1886, Mr. Conkling entered the Department of Civil and Mining Engineering of the Lackawanna Iron and Steel Co., as rodman, continuing with that company (now the Lackawanna Steel Co.) in various capacities. He was made transitman in 1888; Assistant Engineer in 1892; and Chief of the Department in 1894, since which time he had had charge of all the construction work for the company, and entire charge, for the first year and a half, of the construction of the company's Buffalo plant, the design and construction of railroad yards, sewers, canals, harbor work, the South Buffalo R.R. and foundations of all kinds.

Mr. Conkling was Chief Engineer of the South Buffalo R.R.; Chief Civil Engineer of the Lackawanna Steel Co. up to 1901, when he left the direct employ of the company to practice consulting civil engineering in Buffalo, during which time the surveys, plans and estimates were made for the Buffalo, Depew & Lake Erie R.R., a terminal freight railroad to be built around the City of Buffalo.

In 1907 the original design of Lackawanna steel sheet piling was patented. Mr. Conkling designed and patented modifications of the original design and was instrumental in bringing to a commercial culmination the shapes of Lackawanna steel sheet piling now rolled by that company. In 1913 the consulting work of this character had reached such a magnitude that Mr. Conkling returned to the Lackawanna Steel Co. as Chief Engineer of the Steel Sheet Piling Engineering Department, which position he held until the time of his death.

Automobile Makes Record Across Continent

An automobile (Cadillac stock eight-cylinder roadster) driven by E. G. Baker and W. F. Sturm, of Indianapolis, made the transcontinental trip from Los Angeles to New York City in 7 days, 11 hr. 53 min. The start was made from Los Angeles on May 8 at 12:01 a.m. and finished May 15 at 2:53 p.m., covering a total distance of 3,471 mi. Throughout the trip the two men secured about 18 hr. sleep.

The Keaumuku Road on Hawaii, which encircles the entire island, is about complete. It is 240 mi. long. The round journey can be made by automobile in two days.

Municipal Ownership of Gas and Electric Light plants at Phoenix, Ariz., is proposed, with the possible purchase of electric current from the Roosevelt Dam hydro-electric plant of the United States Reclamation Service. Preliminary plans and estimates are to be made by Burns & McDowell, consulting engineers, Interstate Building, Kansas City, Mo.

A Disastrous Fire in Ellendale, N. D., on May 10, practically destroyed the town. The damage is estimated at $400,000, the insurance at $150,000. The fire started at night in a livery stable and was soon distributed about the town by a 40-mi. gale. The local fire department was inadequate to cope with such an emergency and 85 buildings were burned—which left only a half-dozen standing—before aid could be obtained from outside.

A Washout on a Concrete-Lined Ditch caused damage recently at Sioux Falls, S. D. To prevent the flooding of valuable land a flood-diversion ditch was cut from one channel of the river to a parallel channel, the ditch ending in a concrete-lined chute down a bluff. The toe of the concrete not being protected, a flood in the river scoured it out so that it failed, and the chute was broken. The current of water coming from the ditch scoured out a deep cut in the face of the bluff.

The New York City Bridge Department is to be superseded by a new and larger Department of Plant and Structures, according to the provisions of a bill recently made law by the governor's signature. The new scheme was fully outlined in "Engineering News," Apr. 13, 1916, p. 722. The main change will be the inclusion under one head of the 71 repair shops now operated separately by various municipal departments.

A Building-Trades Strike in St. Louis was called at noon on May 6. The number of workmen involved is given as 7,000 and the cause of the strike is the refusal of an increased wage scale by the contractors of St. Louis. Local reports

state that every contractor in St. Louis is affected by the strike, with the exception of eight small concerns who have signed agreements with the unions. The big contractors refuse to recognize the International Union of Hod Carriers.

Free Automobile-Parking Spaces are being built in St. Louis to take care of the conditions that will obtain after May 27, when an ordinance goes into effect prohibiting the parking of automobiles for more than two hours in the streets of a defined congested district. The construction of the parking spaces started on May 7. Red signs designating the congested district will be placed under all street signs at the corners in the section in which parking is prohibited. Only licensed taxicabs will be permitted to park for more than two hours in the congested district.

Dry Dock No. 1 at Balboa, the Pacific terminus of the Panama Canal, has been practically completed and was turned over by the Division of Terminal Construction to the Mechanical Division for operation and maintenance on May 1. The dock is 1,044 ft. long, 110 ft. wide at the entrance, and has a depth over the keel blocks of 35 ft. at mean tide. The dock was built behind the protection of a coffer-dam. A gap 100 ft. wide was blasted through this coffer-dam on Apr. 23 admitting the water from outside into the lock. The blast was made with 14,500 lb. of 60% dynamite.

Geodetic Connection between Mexico and United States—The Secretary of Commerce announces the completion of the work at the Rio Grande to the westward of Brownsville, Tex., and Matamoras, Mex., which connects the triangulation systems of the United States and of Mexico. In the United States the arc of primary triangulation extends from the northwestern part of Minnesota southward along the 98th meridian to the Rio Grande, and Mexico had extended an arc of primary triangulation along the 98th meridian from its Pacific coast to the Rio Grande. The length of the completed arc is 2,270 miles.

Double-Tracking on the Chicago & Northwestern Ry. for about two miles west of Cedar Rapids, Iowa, will complete the double-tracking between Chicago and Omaha. The grading is very light (about 25,000 cu.yd.), and all excavation will be done by hand. Part of the roadbed widening is done by shoveling direct from borrow pits to make the shallow fill. In cuts, the ground is plowed and the earth shoveled into 1½-yd. Western dump cars on a construction track of 2-ft. gage. With this small equipment, the work can be done along the edge of the roadbed without interfering with traffic. The contractors are White & Duffy, of Chicago. The work is under the direction of M. E. Thomas, Division Engineer, at Boone, Iowa.

Two California Irrigation District Projects, each pumping water from wells for distribution through pipes, each including booster pumps, and each having as its chief engineer Stephen E. Kieffer, 57 Post St., San Francisco, Calif., will reach the contract stage the latter part of June. The Lindsay-Strathmore Irrigation District (Secretary, C. W. Wright, Lindsay, Calif.) expects to vote $1,400,000 of bonds to irrigate 15,775 acres of citrus lands. It proposes to sink 37 wells upon a 1,200-acre tract in the Kaweah River delta. The wells are expected to give a total yield of 75 cu.ft. per sec. or 26,000 acre-feet for the season. Each well will be equipped with a direct-connected electric-driven deep-well turbine pump, operating under a total head of 100 ft., delivering into a 60-in. reinforced-concrete pipe 3½ mi. long. This pipe will deliver into a reinforced-concrete-lined low-level ditch 6.25 mi. long, having a grade of 1.92 ft. per mi. At the lower end of this ditch three 16-in. horizontal, single-stage centrifugal pumps direct connected to 500-hp. motors and two 10-in. pumps of the same type with 200-hp. motors will deliver water against a head of 160 ft. into a reinforced-concrete-lined high-level ditch 5.25 mi. long, on a grade of 5 ft. per mi. A boosting station on one of the main pipe lines will lift water 160 ft. more to high-level ditch No. 2, from which pipe will supply the highest land on the district. The boosting station will have two 8-in. pumps like the others just described, driven by 125-hp. motors. The mains and laterals supplied from the two high-level ditches will range in size from 36 to 6 in., total 95 mi. in length, and deliver water under pressure to same point "opposite every tract of land." Pipe above 12 in. will be of "protected" riveted steel and less than 12 in., either the same material or reinforced concrete. The Terra Bella Irrigation District (Secretary, E. R. Clemens, Terra Bella, Calif.) expects to vote $1,000,000 bonds for works to irrigate 12,500 acres, but apparently only half this sum will be expended at the outset. The supply of 65 cu.ft. per sec. will be from about 60 wells and also from "infiltration galleries" consisting of open-jointed cement pipe laid in the bed of Deer Creek. There will be a pump to each well, delivering to a main pumping station, and also five booster stations. The well pumps and the main pumping stations will have equipments similar in type to those for the other district. The main station and booster station No. 1 will contain two 12-in., two [illegible] and two 8-in. pumps and 250- and 125-hp. motors, operating against a head of 120 ft. Booster Station No. 2 will receive infiltration-gallery water and deliver it by means of two 12-in. pumps and 25-hp. motors. Booster Station No. 3 will deliver gallery and well water under 170 ft. head to the same zone as with No. 2, by means of 8-in. pumps and 75-hp. motors. The other two boosting stations will take water from initial boosting stations and deliver it at heads of 80, 100 and 160 ft., these pumps being 4- and 6-in. The distribution system will comprise 80 mi. of 6- to 30-in. pipe, of material similar to that in the other district, delivering water at a point opposite every 20-acre tract.

PERSONALS

Mr. J. C. Townley has been appointed City Superintendent of Ithaca, N. Y., succeeding Martin Conlon.

Mr. Hugh Bennett has been elected Commissioner of Public Works at Ada, Okla. Mr. Bennett was formerly employed as a driver by the Ada Ice and Cold Storage Co.

Mr. W. L. Miller, formerly Superintendent of Construction and Distribution of the Northern States Power Co., has been appointed Manager of the Interstate Power Co., with headquarters at Galena, Ill.

Mr. William Cotter formerly President of the Pere Marquette R.R., has been elected President of the Manufacturers' Ry. and the St. Louis & O'Fallon Ry. He succeeds George F. Moore, who has resigned on account of ill health.

Mr. William E. Foss, M. Am. Soc. C. E., has been appointed Chief Engineer of the Metropolitan Water and Sewerage Board of Massachusetts. He has been Acting Chief Engineer since the death of Dexter Brackett in August, 1915.

Mr. J. F. Carmichael has recently resigned as Construction Foreman with Montague-O'Reilly Co. to take a similar position with A. Guthrie & Co. on the lining of the Oregon-Washington R.R. & Navigation Co.'s tunnel at Portland, Ore.

Mr. W. Cooper Campbell, Assoc. M. Am. Soc. C. E., has resigned as Superintendent of Public Works of Columbus, Ga. He will be located in Charlotte, N. C., where he recently secured a $100,000 street and sidewalk paving contract with that city.

Mr. F. L. R. Francisco, M. Am. Soc. C. E., Consulting Engineer, New York City, has been named by Mayor Thompson of Chicago as the city's representative on the Board of Supervising Engineers of the Railway Terminals Commission. Mr. Francisco succeeds E. W. Bemis.

Mr. O. E. Thomas has been appointed District Sales Manager of the Terry Steam Turbine Co., Hartford, Conn., for a territory covering Arizona and the southern portions of California and Nevada. His headquarters will be at 626 Washington Building, Los Angeles, Calif.

Messrs. William H. Coverdale, M. Am. Soc. C. E., and Walter W. Colpitts, M. Am. Soc. C. E., announce that the practice of W. H. Coverdale & Co., Inc., Consulting Engineers, will hereafter be conducted under the firm name of Coverdale & Colpitts, at 66 Broadway, New York City.

Mr. Edward R. Stapley has resigned as Instructor in Civil Engineering at Cornell University to become Resident Engineer of Wilson, N. C., which now has under construction a system of water-works, a municipal gas plant, and street-paving work to the amount of a half million dollars.

Mr. Schley Gordy has been elected Superintendent of Public Works of Columbus, Ga. He fills the vacancy caused by the resignation of Mr. Cooper Campbell. Mr. Gordy is a graduate of the Alabama Polytechnic Institute and has been assistant to Mr. Campbell for the last six years.

Mr. Frank Strong has been appointed Division Engineer of Maintenance-of-Way of the Salt Lake division of the San Pedro, Los Angeles & Salt Lake R.R. to succeed R. K. Brown, promoted to Engineer of Maintenance-of-Way of that railroad. Mr. Strong's headquarters will be in Salt Lake City, Utah.

Mr. Earle B. Norris, M. Am. Soc. M. E., for several years past Associate Professor of Mechanical Engineering at the University of Wisconsin, has been engaged as Industrial Commissioner of the St. Paul (Minn.) Association of Commerce. Mr. Norris graduated from Pennsylvania State College in 1904, and has since had wide experience in varied manufacturing lines, including agricultural-implement and automobile factories.

OBITUARY

Prof. Leon Henri Carbonnier, former Chancellor of the University of Georgia, died at Augusta, Ga., on May 3. He was born in Lorens, Brittany, in 1837, and educated at St. Cyr, the French military academy. Prof. Carbonnier came to America during the Civil War. He enlisted in the Confederate Army and at the close of the war was selected to create a department of engineering at the University of Georgia. He was later elected to the chair of physics and astronomy.

Henry Rohwer, M. Am. Soc. C. E., Consulting Engineer, died at his home in St. Louis, Mo., on May 7, at 68 years of age. He was born in Holstein, Germany, and studied in the technical schools there. In 1869 he came to the United States and immediately was engaged as Chief Engineer on the construction of the Burlington & Missouri River R.R. in Nebraska. In 1876 he was appointed City Engineer of Omaha, in which capacity he served for five years. Later he was connected with the Oregon Short Line R.R., Omaha Belt Ry. and Missouri Pacific Ry. He was Chief Engineer of the last-mentioned railroad from 1901 to 1905 and Consulting Engineer for the system until he took up private practice several years later.

William Stanley, Fel. Am. Inst. E. E., former head of the Stanley Electric Manufacturing Co. and Stanley Instrument Co., died at his home in Great Barrington, Mass., on May 14, in his 59th year. Mr. Stanley at the age of 32 built the first alternating-current device adapted to the transmission of light and power over great distances. He held the Edison medal, regarded as the highest award for electrical attainment in this country. He was born in Brooklyn and graduated from Williston Seminary, Easthampton, Mass. He entered Yale University in 1881, but left before completing his course to take up experimental work. From 1885 Mr. Stanley was Chief Engineer of the Westinghouse Electric Co., and in 1890 became head of the Stanley Electric Manufacturing Co. He was connected with the Stanley Instrument Co. from 1898 to 1903.

ENGINEERING SOCIETIES

NATIONAL ELECTRIC LIGHT ASSOCIATION.
May 22-26. Convention in Chicago. Secy., T. C. Martin, 29 W. 39th St., New York City.

MASTER BOILER MAKERS' ASSOCIATION.
May 23-26. Annual meeting in Cleveland. Secy., H. D. Vought, 95 Liberty St., New York City.

AMERICAN IRON AND STEEL INSTITUTE.
May 26-27. General meeting in New York City. Secy., J. T. McCleary, 61 Broadway, New York City.

NATIONAL CONFERENCE ON CITY PLANNING.
June 5-7. Conference in Cleveland. Secy., Flavel Shurtleff, 19 Congress St., Boston, Mass.

AMERICAN WATER-WORKS ASSOCIATION.
June 5-9. Convention in New York City. Secy., J. M. Diven, 47 State St., Troy, N. Y.

SOCIETY OF AUTOMOBILE ENGINEERS.
June 12-16. Summer meeting (cruise on Lake Huron and Georgian Bay). Secy., Coker F. Clarkson, 29 W. 39th St., New York City.

MASTER CAR BUILDERS' ASSOCIATION.
June 14-16. Annual meeting, Atlantic City, N. J. Secy., Jos. W. Taylor, Karpen Bldg., Chicago.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
June 14-17. Eighth semiannual meeting. Cleveland. Secy., I. C. Olsen, Cooper Union, New York City.

RAILWAY SUPPLY MANUFACTURERS' ASSOCIATION.
June 14-21. Convention in Atlantic City. Secy., J. D. Conway, 2136 Oliver Bldg., Pittsburgh.

SOCIETY OF RAILWAY CLUB SECRETARIES.
June 16-17. Annual meeting in Atlantic City. Secy., H. D. Vought, 95 Liberty St., New York City.

AMERICAN RAILWAY MASTER MECHANICS ASSOCIATION.
June 19-21. Annual meeting, Atlantic City, N. J. Secy., Jos. W. Taylor, Karpen Bldg., Chicago.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION
June 19-22. Annual meeting in Charlottesville, Va. Secy., F. L. Bishop, University of Pittsburgh, Pittsburgh.

TRI-STATE WATER AND LIGHT ASSOCIATION OF THE CAROLINAS AND GEORGIA.
June 21-23. Annual convention at Isle of Pines, S. C. Secy., W. F. Stieglitz, Columbia, S. C.

NATIONAL GAS-ENGINE ASSOCIATION.
June 27-29. Annual convention in Chicago. Secy., H. R. Brate, Lakemont, N. Y.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
June 27-30. Annual meeting in Pittsburgh. Secy., Charles Warren Hunt, 220 West 57th St., New York City.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 27-30. Annual meeting in Atlantic City. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia, Penn.

The Air Brake Association held its 23rd annual meeting at Atlanta, Ga., May 2 to 5. The officers elected were President, T. F. Dow; vice-presidents, C. H. Weaver, C. W. Martin, and F. J. Barry; chairman of the executive committee, T. F. Lyons; secretary, F. M. Nellis.

The Canadian Railway Club at its recent annual meeting elected the following officers: President, R. M. Hannaford; vice-presidents, G. E. Smart, Prof. Keay; treasurer, W. H. Stewart. James Powell, Chief Draftsman, Motive Power Dept., Grand Trunk Ry., Montreal, was reëlected secretary.

The Georgia Drainage Association held its annual meeting at Monroe, Ga., May 3 to 5. The need of draining Georgia swamp lands was discussed. These lands compose one-fourth of the area of the state and amount to 2,700,000 acres. It is proposed to introduce legislation giving state aid to communities desiring drainage.

The American Institute of Chemical Engineers will hold its eighth semi-annual meeting in Cleveland, June 14 to 17. The usual number of inspection trips will be made. A smoker and entertainment will be given by the local committee at 9 p.m., June 14, while the banquet will be held at the Statler Hotel on June 15. Among the papers to be presented is "Purification of Sewage by Aeration in the Presence of Activated Sludge," by Edward Bartow.

American Association of Engineers—The first annual meeting was held at the rooms of the Western Society of Engineers, Chicago, on May 9 and 10. A session was held each afternoon, but soon adjourned as only about a dozen members were present. No technical papers were presented. About 100 members and guests attended the dinner, at which addresses on military preparedness in relation to the engineer were made by Capt. Reilly (Illinois National Guard), Henry A. Allen, consulting engineer, and others. The report of the secretary showed a membership of over 600, and reviewed the association's activities in regard to securing positions for engineers. A resolution was passed offering assistance to the United States Government in securing lists of engineers, with a view to military organization. The president elected for the year 1915-16 is Garrison Babcock, consulting engineer, Chicago. Arthur Kneisel, Chicago, is secretary.

Appliances and Materials

Dump Wagon with Door Control

The dump wagon shown in the accompanying view has individual control of the bottom doors as one of its special features. To release the doors, the driver presses his feet on a pair of pedal levers, thus withdrawing the lugs that hold the carrying rods. Each door can be closed by one movement of a cam lever. To enable two kinds of material to be carried in one load, or two half loads to be delivered on different jobs temporary partition is placed lengthwise in the middle of the wagon.

The body is 72x38 in. at the bottom, with sides flaring to 82x48 in. at the top. Its height is about 5 ft. The capacity is 1½ yd. within the fixed sides, or 2 yd. with the hinged

DUMP WAGON WITH SEPARATE DOOR CONTROL

sideboards raised. The doors are about 21x76 in., each with four heavy iron hinges across the full width. These are supported by rods of 1¾-in. steel, which carry the greater proportion of the load and distribute the weight equally between the axles. The wheels are 36 and 54 in. in diameter, with 4-in. tires (3-in. if desired). The wheelbase is only 7 ft. 2 in. The 2-yd. wagon weighs complete about 2,000 lb. There is a larger size having a capacity of 3 to 4 yd. These wagons are manufactured by the American Dump Wagon Co., Cedar Rapids, Iowa.

Country-House Water-Works

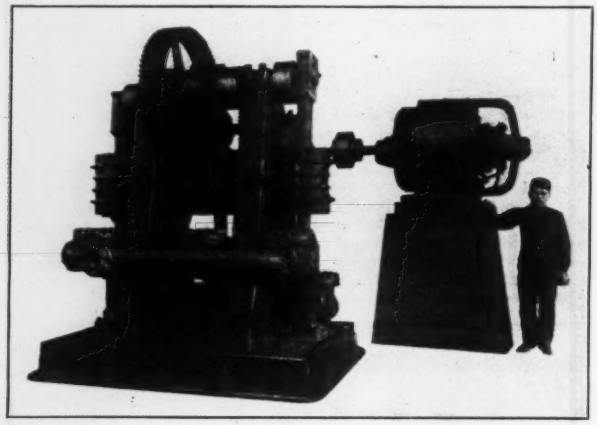
A complete and self-contained pump and storage-tank unit for farms and country houses, known as the "Electri-Pression" outfit, has been designed by the Hill Pump Co., of Anderson, Ind. On an iron sub-base are a motor-driven pump, automatic switch, air valve, water-relief valve, suction- and service-pipe connections and pneumatic-pressure storage tank. The pump ordinarily starts when the pressure drops to 25 lb. per sq.in. or below, and power is cut off at 40 lb.

* * *

Large High-Pressure Pump

The accompanying view shows a new vertical triplex pump designed and built recently by the Hydraulic Press Manufacturing Co., Mount Gilead, Ohio, for delivering a large volume of water against a high pressure. The capacity depends on the size of plungers—4- to 5¾-in. being used, giving capacities respectively of 88 gal. per min. against 1,700 lb. per sq.in. and 183 gal. against 800 lb. The stroke is 12 in. and the normal speed 45 strokes per min.

On account of the large volume of water handled, each cylinder is equipped with pot valves for both the suction and delivery chambers, allowing lighter checks with smaller lift,



TRIPLEX PUMPS WITH POT VALVES FOR EACH CYLINDER

cutting down the slip from that of single-valve triplex pumps of large water capacity.

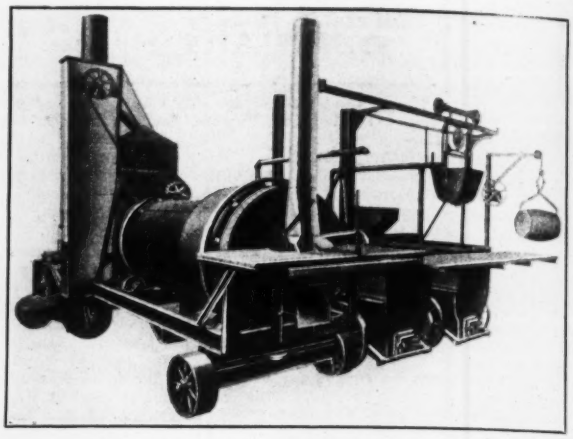
This pump is designed for direct-connected motor drive only and requires 100 hp. It has a double reduction of gears, the first being 5 to 1 and the second 3 to 1. The height of the pump is 10 ft., while the floor space of the pump without the motor is 8 ft. by 5 ft. 9 in.

* * *

Portable Asphalt Plants

Asphalt plants of the designs evolved by Warren Brothers Co., of Boston, for their own work of laying bituminous pavements and roads are now being sold to all who desire to purchase. One of the most useful of their designs has proved to be the portable plant, which had to be low in first cost and maintenance, but sufficiently mobile for use for street repairs and small contracts and on state and county roads. Such a plant, as shown in the accompanying view, comprises a boiler and engine, storage bin, continuous bucket elevator, revolving drier and mixer, two melting kettles and a barrel hoist.

In operation a batch of mineral aggregate (about 3,000 lb.) is loaded into measuring wheelbarrows, dumped into the elevator and held in the storage bin until the previous batch leaves the drier. Then the fresh charge is discharged from the bin through an outlet gate, controlled by the operator on the mixing platform. Thus there are five batches at the plant —one just discharged from the mixer, one in the mixer, one in the drier, one in the bin and one in the wheelbarrows. In the drier a spiral flight carried by the shell works the material forward to a reversing gate that discharges back toward the drier center or forward into the mixer. In the mixer compartment a spiral flight on the shell works the charge forward, and a reversed interior spiral works the top of the batch backward. Oil fuel is burned in a combustion chamber and the hot gases passed through the drier and mixer. It is reported that asphalt topping, open mixture or Topeka-specification mixture can be mixed equally well and without changes of plant. A batch is kept large enough so that good uniformity of product is maintained. Eleven men are required for full-capacity operation.



WARREN'S PORTABLE ASPHALT PLANT

The entire plant except the two kettles is mounted on one truck, weighing 29,000 lb. The plant with kettles, tools, etc., weighs 39,500 lb. The boiler is rated for 35 hp. and is built acording to the A. S. M. E. code. The engine has an 8-in. cylinder and 6-in. stroke. Such a plant costs complete $5,500 (f.o.b. Boston).

* * *

Gyratory Sand Screen

A portable sand screen for contractors and foundrymen has been put on the market by the Great Western Manufacturing Co., Leavenworth, Kan. The device, a view of which is shown in the accompanying figure, is called the Combs Gyratory Riddle. It consists of a frame carrying at its bottom a removable sieve and hung from its top crossbar a shaft

COMBS GYRATORY RIDDLE OR SAND SIEVE

which pivots at the top and which at the bottom revolves around a circular guide. This shaft, driven by a Westinghouse totally inclosed ½-hp. vertical motor, imparts the gyratory motion that sifts the sand. The sieves may be removed at will, either to dump oversizes or to change the mesh. The machine may be hung from a crossbeam or a trolley.

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Agencies and Stocks in Principal Cities

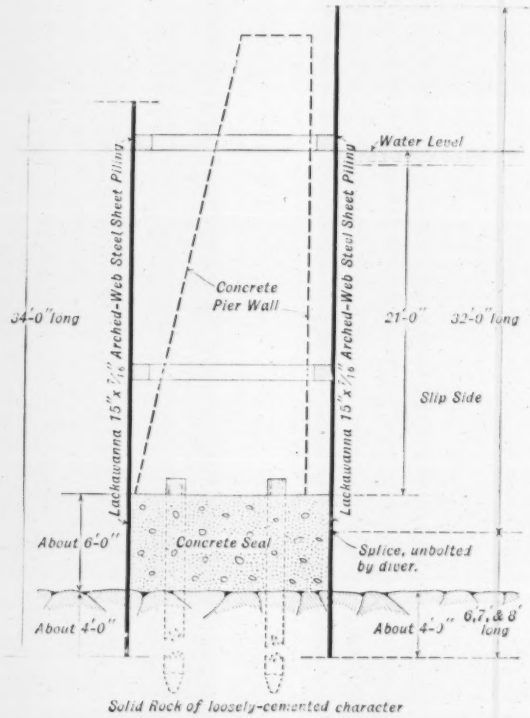
4,000 Lineal Feet of Pier Wall Constructed by Florida East Coast Railway in Cofferdams of Lackawanna Steel Sheet Piling

The cofferdams for building the new pier wall at Key West, Fla. were of Lackawanna 15-in. by 7/16-in. Arched-Web Steel Sheet Piling, which had to be driven into about 4 feet of typical Florida lime rock. Each finished and excavated cofferdam was internally braced with two sets of waling to withstand the head from 27 feet of water, and watertightness of the sheet piling wall was also essential.

Enough Lackawanna Steel Sheet Piling was purchased in spliced sections to make four cofferdams each 60 feet long.

The bottom and top portions of each sheet piling section were bolted together for driving and the bottom parts, 6 to 8 feet in length, driven into the rock, were left in place to prevent disintegration of the rock and to protect the toe of the wall against destructive action from tides. On completion of the wall at one location, the splices in the steel sheet piling were unbolted by divers and the top parts of all piling sections removed for use elsewhere.

The concrete seal, resting upon rock and bearing piles was about 6 feet thick and poured under water, leaving a depth of 21 feet below water level to be kept dry during construction. The watertightness of interlocked joints of the Lackawanna Steel Sheet Piling made the pumping a small matter, and no difficulty was experienced in maintaining satisfactory working conditions.



Prominent railroads, like other users, are great believers in Lackawanna Steel Sheet Piling, not only for its general utility, but for economy, as it may often be used several times before finally placed in a permanent installation.

Our literature should be in the hands of all managing and contracting engineers, and those with immediate steel sheet piling requirements will find the free advice of our Steel Sheet Piling Engineers helpful.

LACKAWANNA STEEL COMPANY

General Sales Office and Works: Lackawanna, N. Y.

NEW YORK	CLEVELAND	ST. LOUIS
BOSTON	CINCINNATI	ATLANTA
BUFFALO	CHICAGO	SAN FRANCISCO
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Licensees for the manufacture of Lackawanna Steel Sheet Piling

For Great Britain and British Colonies in the Eastern Hemisphere, Cargo-Fleet-Iron Co., Ltd., Middlesborough, England. For France, Italy, Spain, French Colonies and Protectorates, Italian Colonies and Spanish Colonies in the Eastern Hemisphere: Cie Des Forges & Aciéries de la Marine et d'Homécourt, Paris, France.

240

Engineering News

VOLUME 75 MAY 25, 1916 NUMBER 21

New Water Tunnel at Chicago

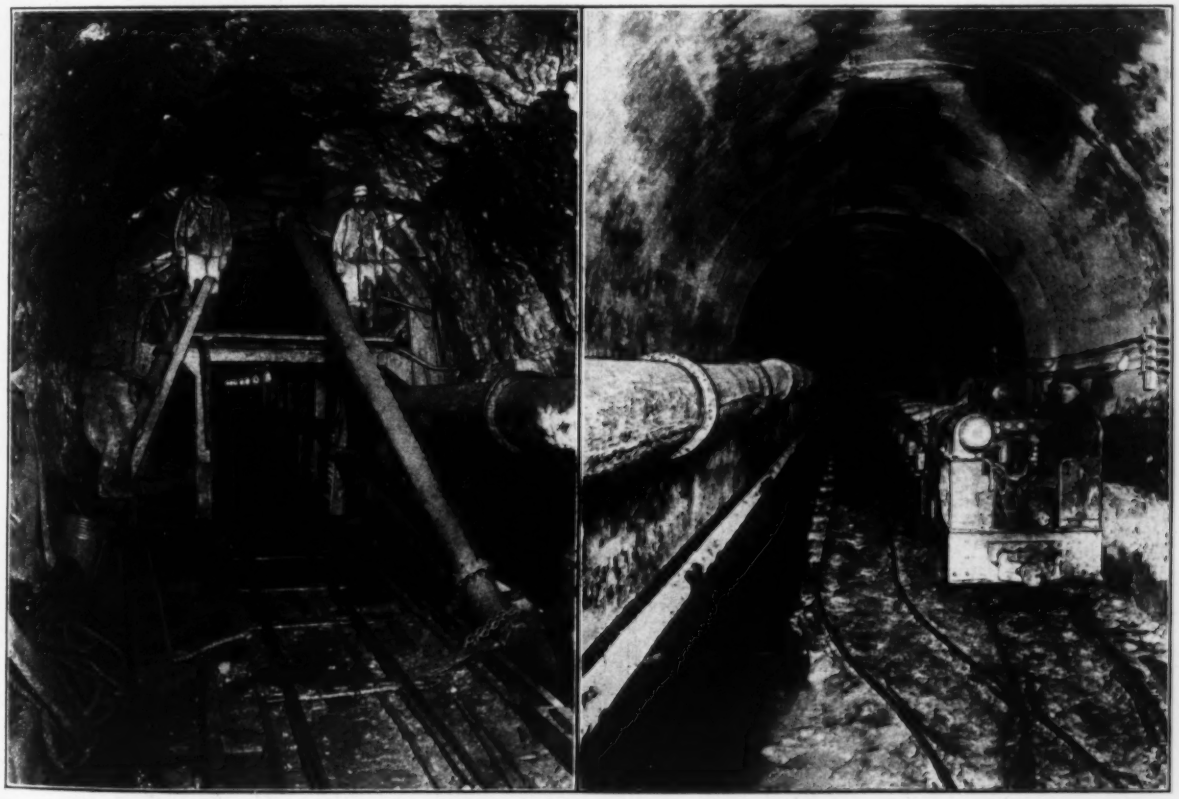
SYNOPSIS—New intake tunnel for Chicago avoids danger of soft ground by going deep enough to strike sound rock. Built by city day-labor. Top-heading system worked on two-shift plan found best; rates of advance up to 22 ft. per day. Economy in handling spoil accomplished by screening out fine rock in the tunnel and using it for immediate mixing and placing of lining concrete, so that only the oversize rock goes out of the tunnel. Concrete blown into lining with pneumatic mixer and conveyor.

City day-labor is producing rapid progress and low cost in the construction of the Wilson Ave. intake tunnel of the Chicago water-supply system. Several ingenious features of the plant equipment and methods of working, devised by the city's engineers and executed under their direction, are responsible for these results.

The tunnel will be about 8 mi. long; of the total length under the lake, half is from the shore shaft to an intake shaft and crib. The land portion extends under Wilson Ave. to a new pumping station serving the northwest section of the city. It has also a short branch tunnel to furnish additional supply to the present Lake View pumping station. The main tunnel is 12x12 ft. and 13x13 ft., with vertical sides, semicircular roof and invert floor. The flow capacity is 350,000,000 gal. per day. The tunnel was described in *Engineering News*, Apr. 22, 1915. Figs. 1 and 2 are views in the drift and completed tunnel under the lake.

To keep the entire tunnel in solid rock, it was placed at an unprecendented depth—160 ft.—the prior intake tunnels having encountered many construction difficulties due to soft ground. Diamond-drill borings were made along the line before deciding on the depth of the tunnel.

Besides the intake shaft, shore shaft and pumping-station shaft, there are two intermediate working shafts



FIGS. 1 AND 2. THE WILSON AVE. LAKE TUNNEL—ROUGH AND LINED

At left, 8-in. blow pipe from MacMichael concrete mixer going through dam over Blaw form section. Run-of-screen aggregate is used, up to 4-in. size, without sand addition, yet a remarkably even surface is obtained, as seen at right. The upper pipe in both views is the sheet-steel ventilation pipe, jointed with rubber-packed loose flanges, and so light that a 20-ft. length can be handled by two men. The clear air in both views is due to excellence of ventilation and absence of leakage except near face

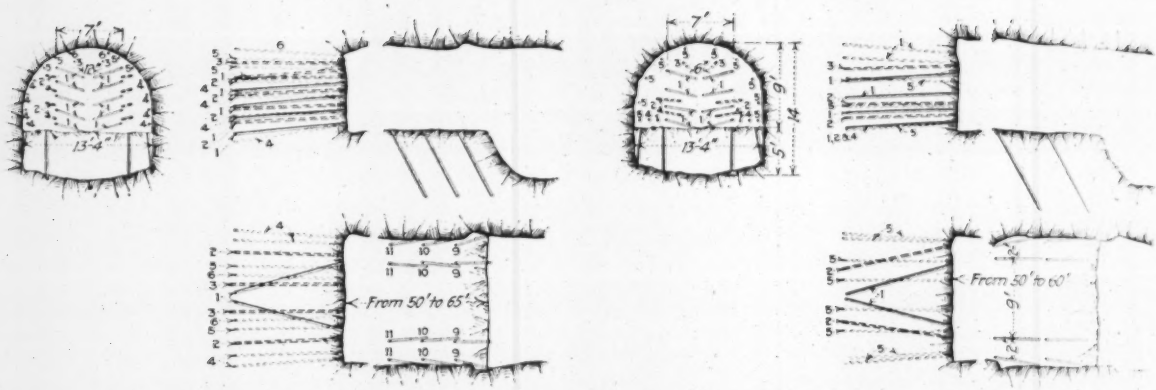


FIG. 3. ALTERNATIVE METHODS OF DRIVING THE TUNNEL ON THE TOP HEADING SYSTEM

on the land portion of the tunnel. A contract was let for the intake end of the work, as this included the steel crib and the city did not wish to acquire the floating equipment necessary for work in the lake.

The design and execution of the work are under the direction of John Ericson, City Engineer. The construction is in direct charge of Henry W. Clausen, Engineer of Water-Works Construction, who is practically the general superintendent of all construction work for the water-works. The following description is prepared from a paper read by Mr. Clausen at a meeting of the Western Society of Engineers, at Chicago.

Organization of Forces

The work at each shaft is under an assistant engineer and a tunnel foreman, the latter reporting to the engineer. The heading foreman (in charge of drilling and blasting), the mucking boss, the concrete foreman, the track-gang boss, the hoisting enginemen and such unattached labor as top laborers and pumpmen all report to the tunnel foreman.

Union labor is employed at the union scale of wages, which is higher than for tunnel work in other parts of the country. The lowest pay is $4.40 per day, for muckers. Drillers and miners get $5; skilled mechanics, $6, with overtime.

Headhouses and Shaft Equipment

At some shafts, where space was available, high headhouses and trestles were constructed, so that all muck (stone) might be stored. At other shafts the structures were only high enough for dumping into bins from which the stone was removed daily.

The power used is 220-volt alternating current, transformers being placed to furnish as much as 800 hp. The cost of current averages 13c. per kw.-hr. The Thomas electric hoists are driven by 50-hp. slip-ring motors and give a speed of 200 ft. per min. for 5,000-lb. loads. It is thought that still better results could be obtained by adopting the double-skip method.

Compressed air for the drills and concreting apparatus is furnished by three or four motor-driven Ingersoll-Rand compressors, having a capacity of 600 cu.ft. of free air per min. delivered at 110 lb. pressure. A 7-in. header leads to a vertical receiver 4x12 ft.; from this a 6-in. pipe is carried down the shaft and branches to 4-in. lines in the short drifts, while a 6-in. line is used in the long drift under the lake.

To determine the most efficient drills for the work, different kinds were used at different shafts. The old piston drill and water drill are found to be the most economical in repair; the water drill is the faster (though the difference is not marked) and uses less air. The drills at the face are mounted on both columns and heading bars. The former method seems to have the advantage. Bench holes are drilled from the column or bar as much as possible.

For handling the muck a double-track line of 24 in. gage was laid, having 20-lb. rails and steel ties, with about two wood ties to 20 ft. of track to prevent the steel ties from creeping. Steel side-dump cars of 1-yd. capacity are used.

When the drifts became too long for mule haulage, 5-ton Baldwin gasoline locomotives were used, having four-cylinder 40-hp. engines. They can run at 8 mi. per hr. and handle usually 20 to 25 loaded cars, but have handled as many as 57 cars. The exhaust is passed through a water box, and ordinarily the escaping gases are sufficiently diluted to be unobjectionable.

Ventilation and Drainage

An exceptionally large ventilating capacity is provided and has helped materially in the rapid progress by quickly removing the smoke and gases after blasting. For each drift up to 6,000 ft. in length, there is a centrifugal compressor with a capacity of 5,000 cu.ft. per min. at 1.5 lb. pressure. Longer drifts have two compressors in series, giving the same capacity but at 3 lb. pressure.

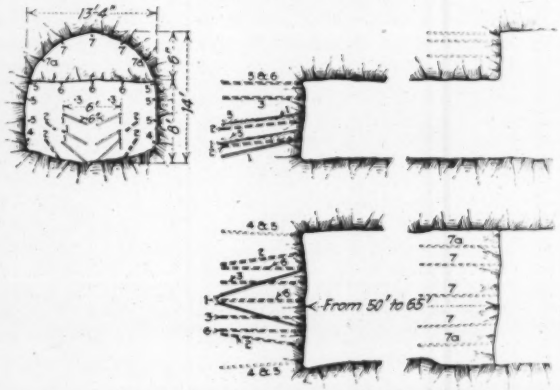


FIG. 4. METHOD OF DRIVING THE TUNNEL WITH A BOTTOM HEADING
Used at one shaft only

Each compressor has a 50-hp. motor. The air is led to within about 100 ft. of the bench in an 18-in. pipe suspended along the side of the tunnel, over the drainage ditch.

The pipe was designed and made specially for this job. Lightness was the controlling consideration. It is of sheet steel, asphalt-coated; the 20-ft. lengths have ends flanged back and fitted with loose malleable-iron flanges. Soft-rubber gaskets are inserted. The pipe is so light that two men can easily carry a 20-ft. length,

ard method of top heading and bench, operating on the two-shift basis, was used at the short shaft and two intermediate land shafts. This method (Fig. 3) involves the drilling of from 28 to 34 holes in the heading and 8 to 12 holes in the bench. The cut holes are from 12 to 14 ft. deep, and some 15-ft. steels were made up in order to increase the shot holes. Alternative methods of driving by the top-heading system are shown in Fig. 3.

The bottom-heading method with breakdown roof, on the three-shift basis, was used in the single heading from

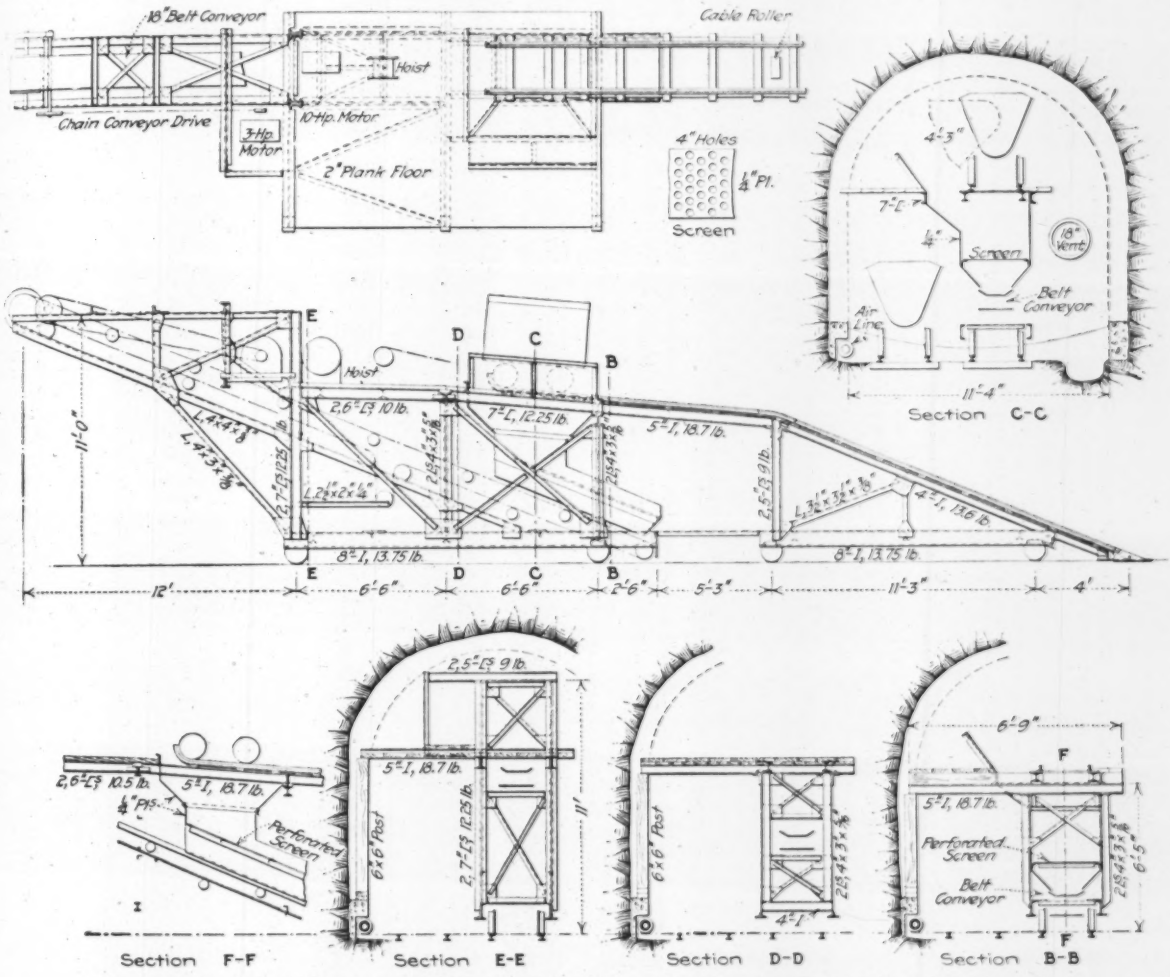


FIG. 5. TRAVELING CONVEYOR FOR DELIVERING ROCK TO THE PNEUMATIC MIXER

which greatly facilitates the moving of the line at concrete forms, etc.

The ventilating system can be used to force the air in or to exhaust the air and smoke after blasting. A bypass with valves provides for this without reversing the compressor. In winter the air blown in is heated.

For drainage two sizes of motor-driven centrifugal pumps are used, to work against heads of about 150 ft.; they are of 1,000 and 300 gal. capacity, with 75- and 20-hp. motors. The tunnel is almost entirely dry, and such water as is encountered enters through the sides, at 4 or 5 ft. above the bottom. No water enters at the roof.

To determine which method of tunneling was the most economical and speedy and best adapted to Chicago conditions, it was decided to try different ones. The standone shaft, where the territory was not so built up, and it was found that no complaints resulted from the blasting operations being carried on during all hours of the day and night. This method (Fig. 4) involves the drilling of about 23 holes in the bottom heading and 5 holes in the roof heading. The cut holes are from 9 ft. to 10 ft. deep.

At the latter shaft an experimental shooting platform was constructed for the purpose of intercepting the rock shot down from the roof, thus avoiding blocking the free passageway to the bottom heading for a certain time while the rock from the roof was being mucked out. The platform was constructed of steel and lasted but a short time, finally becoming so badly bent as to make it of no further use and it was abandoned.

In general the top heading and bench method is the most economical, operated on the two-shift basis. If there is any quantity of water, it can escape freely instead of being blocked by the breakdown shot of the top heading. The second and most important reason is that on the two-shift basis a certain task can be given to the gang, which must be completed before they leave the work. It is the duty of the miners to set up columns,

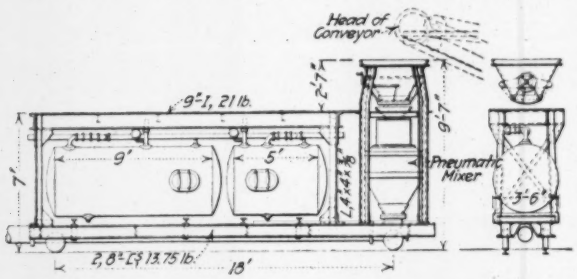


FIG. 6. TRAVELING PNEUMATIC CONCRETE MIXER

drill and load their holes, and shoot their rounds before going home. Likewise it is the duty of the muckers to muck out all the rock from the previous shift. It is understood that the time of the shift ends whenever these tasks are completed.

With a well-organized crew, for a 10- to 12-ft. round, the muckers will complete their work in from 6½ to 7 hr. and the miners in from 7 to 7½ hr. If the gang is not up to standard, it may take from 9 to 10 hr., for which they only receive one day's pay. The fact that a

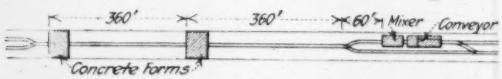


FIG. 7. PLAN SHOWING ARRANGEMENT OF FORMS AND CONCRETING PLANT

shift can be held responsible for a definite amount of work spurs each man to do his part.

In the three-shift method, the gang only works 8 hr. and quits, the succeeding shift taking up the work where the previous shift left off. If the previous gang neglected their work, it is very much harder to place this responsibility without argument and question. This latter fact is of extreme importance when (as in this case) the work is under the civil-service system, because absolute evidence must be forthcoming before a man can be discharged.

The total daily progress was not any greater by the three-shift method, although a greater number of men was employed.

Concrete Mixing and Placing Plant

The concrete is mixed and placed by the MacMichael pneumatic process. The mixing is done in the tunnel itself. The plant includes a conveyor traveler and a concreting traveler, both built of steel (Figs. 5 and 6). The former has an inclined track up which the car loaded with rock is hauled by a cable and 10-hp. electric hoist. The car is dumped at a screen plate having 4-in. circular holes, and the rock passing through falls upon a belt conveyor which delivers it directly to the mixer hopper. The conveyor is driven by a 3-hp. motor and runs at about 150 ft. per min.

The concreting traveler, shown also in Fig. 9 carries the pneumatic mixer and two reserve air tanks of 14 cu.ft. capacity; these are to prevent sudden drops of pressure in the air-supply line due to the large volume of air required for each discharge of the mixer. An 8-in. pipe leads to the forms.

The plant, comprising the two travelers, is moved 200 ft. every 12 days, under an arrangement of work as sketched in Fig. 7. As the forms approach the mixer, the 8-in. pipe is shortened until another shifting of the plant becomes necessary.

The mixer is leased from the Concrete Mixing and Placing Co., of Chicago. The screening and mixing outfit was constructed by the Stephens-Adamson Manufacturing Co., of Chicago, from the engineers' design.

Placing the Concrete Lining

The method usually employed by contractors in tunnels of this size has been to complete the drift before starting the lining of the tunnel, bringing all material to the surface. After the mining was completed, the excavated rock stored on the surface was crushed and screened and made into concrete, which was brought into the tunnel and placed by hand behind forms of steel or wood. From 30 to 35 ft. per day was lined in this way. When the drift was long, the concrete sometimes had its initial set before arriving at the forms. By a radical departure from this method, the Wilson Ave. tunnel secures a great gain of economy.

It was noticed that the muck or excavated rock contained considerable fine material and would make good concrete. Various compressor foundations and other miscellaneous concrete work on top were built with this material. Test cubes also showed satisfactory strength.

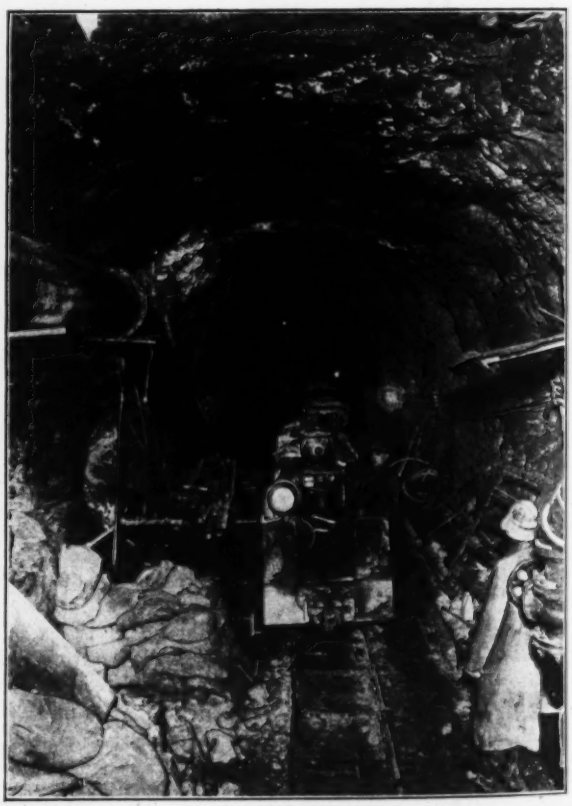


FIG. 8. GASOLINE LOCOMOTIVE AND MUCK TRAIN IN WILSON AVE. LAKE TUNNEL

The rolling stock has automatic couplers and roller bearings

It thus developed that the rock could be used for concrete without previous crushing.

Realizing the possibility of saving time and also of saving the expense of hauling back and forth the material required for the lining, as well as the cost of purchasing crushed stone and sand for the concrete, a method was devised for carrying on both mining and lining simultaneously. For this purpose the screening and mixing machine was installed in the tunnel. It handles all the rock coming from the heading and delivers all rock under 4 in. to the pneumatic mixer. The oversize is rejected and loaded by hand into a car.

The pneumatic mixer delivers the concrete through an 8-in. pipe placed behind the steel forms at a distance of as much as 800 ft. Fig. 1 shows the end of this pipe leading up to the arch. The screening machine and the concrete mixer operate on one track and within the clearance of the final tunnel dimensions.

The forms, Fig. 1 are made of the traveling type. As the mining and lining had to be carried on at the same time, room had to be provided through the forms for transportation of muck to the shaft, with sufficient clearance for the locomotives. These are Blaw forms, constructed of structural shapes and steel plates in 30-ft. sections, and are mounted on roller-bearing wheels running on 70-lb. rails.

By means of this system of working, approximately 60 ft. is lined in two shifts. The net results are that 20 to 22 ft. a day is mined and approximately 60 ft. of tunnel is lined with the excavated material on each working day in each drift.

In advance of the steel forms, concrete guide walls are constructed by hand. Wood forms are used for these, set to true line and grade from the engineer's center line and grade plugs. These concrete walls guide the steel forms so that the finished lining is absolutely true to line and grade. Mr. Clausen states that this is something it was difficult to get a contractor to do, his policy being rather to fit the hole as blasted as near as possible and thus avoid trimming. This would sometimes result in the tunnel being a series of short tangents varying 2 to 6 in. from a straight line.

The Rock-Crushing Plant

At the Lawndale shaft the rock is of a different texture, 50% breaking over 4-in. size. As at this shaft the total excavation was required for concrete, it was decided to put in a crusher. Accordingly, a concreting machine is placed in each drift, and the oversize from the east machine (at the face) is put through the crusher and sent to the west machine in the completed drift.

The crusher was mounted on timbering in an enlarged chamber at the bottom of the shaft. Above it and at one side was a track on which rock cars were run from the shaft cage and dumped directly into the crusher. Beneath was another track for cars to receive the rock.

The disposal of excavated material was a serious problem, particularly at the shore shaft, where there was no available space for storage. The city finally made a contract with the Peoples Crushed Stone Co., which agreed to take the stone away as fast as produced from the shore shaft and to remove the rock piled at the other shafts within a reasonable time after the completion of all the work. The contract provided that crushed stone for the lining of the tunnel should be furnished to the city upon requisition from time to time. The city was thus relieved of considerable expense in the removal of over 400,000 cu.yd. of material. The company erected a crushing and washing plant capable of handling between 750 to 1,000 cu.yd. per 10-hr. day.

FIG. 9. REAR OF CONCRETING MACHINE IN TUNNEL

Progress and Cost

The average daily tunnel excavation is about 20 ft.; on many days as high as 22 and 23 ft. is made. The maximum has been about 26 ft. One reason for the remarkably rapid advance is the rapid clearing of smoke by the ventilation system. On similar work done by contract, the best daily average was 8 ft. A record progress of 15 ft. on one contract left so much trimming to be done afterward that the average daily rate was lower.

When excavating rock at 20 ft. per day, a round trip of the cage is made every 56 sec., 7 sec. being used each at top and bottom for loading a car. The descent would be made in 10 sec. At the bottom of the Lincoln Ave. shaft, in order to facilitate this operation, there is a spare track on one side of the cage to handle empties.

The cost of excavation of 12-ft. tunnel (labor and material) averages $32.94 per ft. The lining was estimated at $15, but is costing less. For all work in 1915, including depreciation of plant, engineering, inspection, excavation, lining and cleaning, the average cost was $61.48 per ft. The cost by contract was estimated at $75 per ft., and on the basis of the lowest bid it would have been $68.20. Contractors considered the time limit of 42 months for the lake tunnel too short, but Mr. Clausen expects to finish the work within 30 months from the time of starting. In fact, it is expected to finish the lake and land tunnels in February and March, 1917, respectively, or 12 months ahead of time.

Failure of Diversion Dam on Salt River Project

SYNOPSIS—Low weir on gravel foundation above Roosevelt dam fails under overtopping flood. Apron, not of sufficient thickness to withstand erosion, wore down to thin section. Report by board of inspecting engineers.

On Jan. 28 of this year the greater part of the diversion dam at the head of the power canal 19 mi. above the Roosevelt dam on the Salt River project of the United States Reclamation Service went out under extreme flood. The dam was in an isolated location where observation of its behavior was necessarily limited, so extensive information as to its condition and its failure is not available. Inasmuch as the dam was one of the much discussed porous-foundation type, such facts as are obtainable regarding its failure should be put on record.

The Roosevelt diversion dam was built in 1906 across the Salt River, some 20 mi. above the Roosevelt dam, then under construction. It is at the head of the power canal leading down to the main dam and was used during the building of that dam to generate power for the construction machinery. Since that time the canal has been continued in service for power purposes, the current generated being sold in the vicinity of Phœnix and Globe. In the future it is intended to be used as an emergency feeder to the Roosevelt power house.

The details of the dam, as shown on the design drawings, are given in Figs. 1 and 2. On those drawings are also shown such modifications of the design as were made during erection. As will be noticed, it consists of a rubble-concrete ogee-section weir or dam 12 ft. high, 18 ft. wide and 400 ft. long, extending between rock-filled buttressed abutments. It is founded on a porous foundation into which penetrate upstream and downstream cutoff walls, 24 in. thick, and 18-in. transverse wal!s spaced every 10 ft. It is backed with a loose rock-fill, and the upstream floor is designed to be paved with large boulders. As mentioned below, however, in construction these boulders were paved with an additional concrete floor.

The failure of the dam is best described by the board of engineers appointed by the Reclamation Service to investigate the matter. This board, composed of H. C. Henny, L. C. Hill and William S. Cone, all of whom have an intimate knowledge of the site and of the design, reported in part as follows:

The present condition of the dam is as follows: From sluiceway wall northward, there are 17 ft. in place, 230 ft. washed away, 45 ft. moved downstream 4.5 ft. and tipped back, 8 ft. broken, but nearly in position, and 100 ft. in place at the north end. The water face of the overflow portion of the dam shows heavy wear for a distance of about 2 ft. below the top.

The sluiceway and headgate works are intact. The north abutment has a crack running downward, starting from a contraction joint at about the middle of its river-front face, but deviating in its downward course at an angle of about 10° in a downstream direction. This crack is open at the top about 1½ in., and at the bottom it is nearly closed. The downstream toe wall of the north abutment is washed away, also the earth-fill that was inclosed within the abutment walls; also most of the downstream-bank riprap.

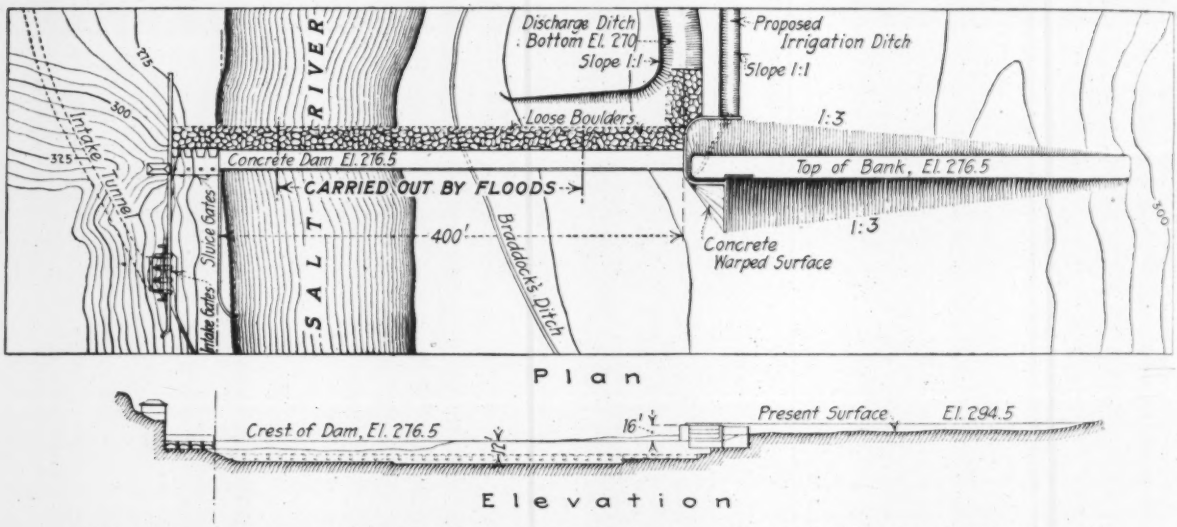


FIG. 1. PLAN AND ELEVATION OF DIVERSION DAM ACROSS SALT RIVER ABOVE ROOSEVELT DAM

The first flood peaked at about 1 p.m. on Jan. 19 at 108,000 sec-ft., when the north-abutment earth dam was slightly overtopped and earth was washed away from back of the abutment without, however, causing a gash or break. The second flood peaked at about the same amount at 6 p.m. on Jan. 28, when the damage to the main structure took place.

The cause of the damage cannot be definitely ascertained. It may be due to wear over the concrete spillway apron from gravel, cobbles and boulders. A small breach in this protection would quickly wash a deep hole that may have undermined the downstream toe of the dam, which rested on gravel. This seems the most plausible explanation. Piping under the dam may have been a momentary feature of destruction, but can hardly be considered the original cause.

It has not been possible, due to continued heavy river flow, to make any accurate survey or determine the depth to which the river channel has cut, the river flow being at present about 3,000 sec.-ft. It is probable that the receding flood will fill, with heavy gravel and sand, deep holes and pockets that may now exist and that the principal work of repair will consist of building of coffer-dams, reconstruction of masonry and

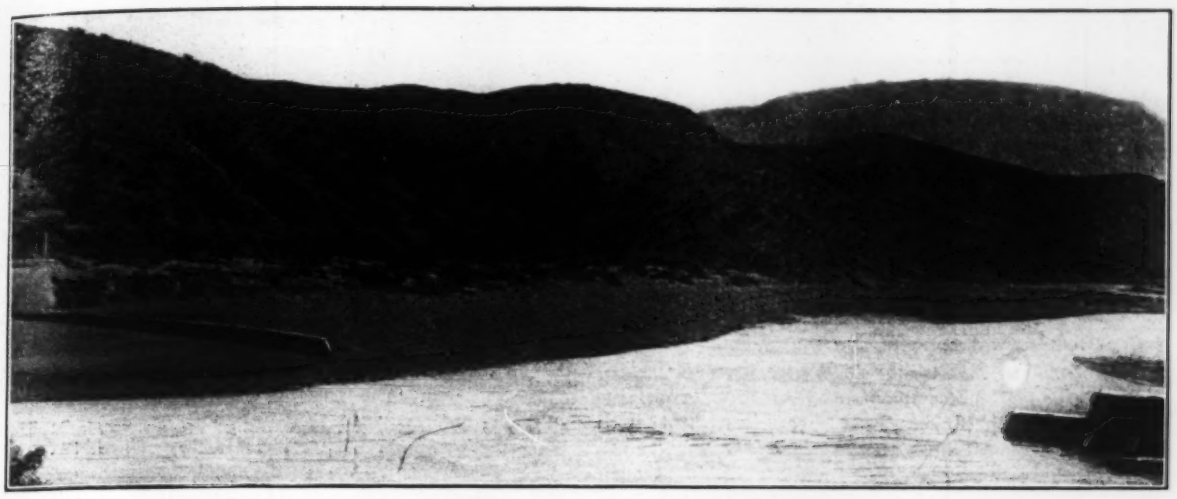


FIG. 3. SITE OF DIVERSION DAM AFTER FAILURE OF JAN. 28, 1916

refill of earth pack of the north abutment. Roughly speaking, 290 ft. of overflow dam and spillway will have to be rebuilt.

In response to further inquiry regarding the dam, L. C. Hill, of the inspecting board and formerly in charge of the projects, writes as follows:

This dam was built under the direct supervision of O. T. Ready, who was the engineer in charge, and the plans for the dam were drawn by A. L. Harris. It was built during the season of 1905, when very heavy floods prevailed in Salt River. The plan that was made up in the office apparently was not exactly the plan followed in the field. To just what depth the two cutoff walls above and below were finally built, I am not now sure. The intention was, however, that these cutoff walls should go down at least 10 ft. below the normal bed of the river in the middle of the stream. In some places it probably went lower than this. At one place in the stream bed there was rather soft material encountered, much softer than in any other part, and here there were a number of piles driven down to depths considerably greater than it was possible to carry the concrete cutoff walls. The apron, which shows on one drawing as being made up of loose rock without any covering, actually was made up of loose rock with a curtain wall at the lower end, and the rock covered on top with about 12 to 18 in. of concrete poured in squares whose dimensions, as I now recollect them, were about 8 ft. on a side. These squares were not absolutely separate. The corners were left joined together.

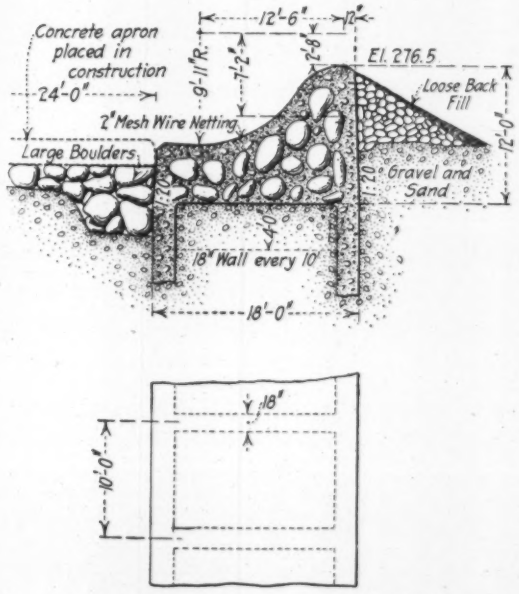


FIG. 2. SECTION THROUGH MAIN WEIR WHICH WENT OUT

I recently inspected this dam with other members of a board. We made inquiries from some young engineers who had happened to be up there some time before either of the large floods had passed over the dam. From talking with these young engineers I learned that the apron seemed to be very badly worn, as they found from walking across the dam on the apron in their bare feet, when there was about a foot or two of water on the apron, that the apron was full of holes from 6 to 8 in. deep. The original apron was left almost smooth, although there was a layer of smooth river boulders worked into the concrete apron, but in no case probably standing above the ordinary level of the apron more than a ½ in. at any point. We examined the upstream face of that part of the dam which is in place, and the concrete looked as if it had been hammered with a sledge hammer for about 2 ft. below the top of the wall. There were evidences that large boulders of 1 ft. to 2 ft. or more in diameter had passed over the dam. The probable cause of failure, although of course not the certain cause, was the wearing out of the apron from the heavy impact of rock carried by the successive floods. No repairs had been made to the face of this apron since it was completed some ten years ago.

There has never been at any time any report of agitation of the water as far down as the end of the apron. From reports made by engineers during the time the Roosevelt dam was building, it appears that when the water reached the depth of 7 ft., more or less, there ceased to be any agitation below the dam, the water passing over in a smooth curve. The greatest agitation occurred with somewhere between 5 and 6 ft. going over the dam, according to reports made several years ago. The fact that the dam had gone through a great many floods of quite considerable magnitude before the big floods of 1916, without any damage to the dam, seems to show that piping was not the primary cause of the failure of the dam. The fact also that it passed successfully through the first and much the larger flood would seemingly corroborate the belief that the failure of the dam was due to rocks breaking up the apron and hence leaving the material just below the toe of the dam exposed to the erosion of the overpouring water. Of course, as soon as this occurred, the dam would fail within a very short time.

The left end of the dam for perhaps 5 or 10 ft. was founded on rock. No other rock appeared at any point along the line of the dam; and the dam was designed for a boulder, sand and gravel foundation and would, I believe, be standing today if the apron had been made of sufficient thickness to sustain the long-continued erosion or if proper repairs had been made to the apron when it was discovered that it was wearing thin or holes were being ground in it.

As stated in the first part of this article, present and future use of the power canal is only that of an emergency feeder to the Roosevelt power house and the failure of the dam at this time has not in any way interfered with the operation of the power plant or of the irrigation systems in Salt River Valley.

Work Done by the U. S. Forest Products Laboratory

Experimental work carried on at the Forest Products Laboratory, maintained by the Forest Service of the United States Department of Agriculture in coöperation with the University of Wisconsin at Madison, Wis., is of direct interest to all industries that depend upon wood in any way. Securing a better and more economical use of wood in all its forms is the object of the laboratory's work. Some of the recent accomplishments are outlined in the following paragraphs. These investigations are for the most part only definite steps in a larger program.

A humidity-regulated kiln has been devised (patented and dedicated to the public) of service in reducing the time for drying—particularly of green wood from the saw. Green white fir has been successfully kiln dried in 43 hr. Unusual and uneven shrinkage of Western woods, notably red cedar, was found to be due to collapse of cell walls during drying. For this wood it was found sufficient to keep the temperature below 135° to 140° so long as the cell walls were wet. The use of sodium fluoride to prevent sap stain on lumber has been successfully developed. This solution also tends to prevent rot.

The consumption of treated wood blocks for paving has fallen off 30% since 1911, owing to trouble from exudation of oil and swelling of the blocks. The Laboratory has succeeded in removing the defects by applying a preliminary and final vacuum in the course of the preservative treatment. The new methods have been adopted by the Committee on Paving of the American Society of Municipal Improvements and by several cities. Better methods of treating piling are now possible to reduce destruction by marine borers. The preservatives are valuable in the following order: Coal-tar creosotes, water-gas-tar creosotes, and wood tars and creosotes. The addition of metallic salts increases the protection. It has been found that creosoted wood can be used in silos without contaminating the ensilage.

Some 70 species of hard wood and 40 species of conifers have been tested (in jars) to determine relative resistance to decay. The junipers and arbor vitæs proved highly durable—Eastern arbor vitæ losing only 7.7% in 12 mo. Resinous hard pines varied from 17 to 58% loss. Sapwood of all conifers except Western red cedar, Western juniper and arbor vitæ lost 60% or more. Great variation has been found in the toxic properties of wood preservatives, showing need of standardization of products. Fungi have been found to increase their resistance to toxic agents, the concentration needed to kill *fomes annosus* rising from 1% to 3% in four generations subjected to preservatives.

An exceedingly unsanitary condition (as to rot fungi) has been found to exist in many lumber yards in the handling of timber, causing local outbreaks of rot in wood buildings. Few precautions are taken to maintain stocks in sound condition or not to sell infected stock to the building trades.

Fireproofing paints for wood have been tested in an experimental firehouse. Of 18 outside paints, five had retarding properties, the retardation being from 1 min. 3 sec. to 2 min. 10 sec. in place of 43 sec. The Laboratory has developed a fireproofing compound that will be patented and dedicated to the public.

Tests of 164 M.ft. b.m. of lumber from [illegible] trees cupped for turpentine (cup and gutter system) showed no difference in the quantity of lumber produced and only ½ to 1% reduction of value.

A drum barker for paper-mill wood has been developed that reduces the waste to 10%. It has been found possible to work this bark up into pulp for low-grade box board. A test instrument has been devised to measure the tearing strength of paper.

In working upon the destructive distillation of hard woods temperature-control apparatus has been devised by which the yield of acetate and alcohol has been increased up to 50%. Ethyl alcohol yield of larches and spruce under digestion has been increased 23%.

Method and Cost of Bitulithic Paving, Pierce Co., Wash.

By David H. White*

This road, paved as described in this article, begins at Alderton, about 15 mi. southeast of Tacoma, Wash., is 5,319 mi. long and ends at Orting. The pavement was laid over a gravel road on alluvial soil. The original grade of the road was utilized as nearly as possible in order to get the benefit of the packed surface for the foundation. The pavement has a 2-in. bitulithic top, 16 ft. wide, containing 49,878 sq.yd., laid on a 5-in. 1:3:6 concrete base, with 6-in. concrete curbs. The number of square yards in the base and curbs is 52,979. The

FIG. 1. SPREADING SAND FOR SEAL COAT

curbs are monolithic with the base. Three-foot bank-run gravel shoulders make the total width of the roadway 23 ft.

The contract was let to the Washington Paving Co. for $76,549, with a 5-yr. maintenance bond costing $500 extra. This made the cost to the county $1.445 per sq. yd., divided as follows: Subgrade and extras, including curbs, 23.4c.; concrete base, 60c.; bitulithic top, 68.6c. The cost per mile was $14,392.

Sand for the bitulithic top and sand and gravel for the concrete base were obtained from a pit owned by the contractors, located about 0.6 mi. from McMillan, where the bitulithic plant was stationed, being 2.2 mi. from one end of the pavement and 3.2 mi. from the other. The average haul for the aggregate for concrete was 1.95 mi., and the average haul for the bitulithic mixture was 1.35 mi. Crushed granite rock was furnished to the contractor from the county-owned quarry at Kapowsin

*County Engineer, Pierce County, Tacoma, Wash.

at cost, for use in the bitulithic top. The contractor paid freight on the rock at 1c. per ton per mile from Kapowsin to McMillan, a distance of 13 mi. Cement cost the contractor $2.30 per bbl. delivered on the work, with a rebate of 40c. per bbl. for sacks.

In the construction of this work a one-car asphalt plant was used by changing the sand bin into four compartments. The plant consists of a rotary drum to heat the sand and rock (oil being used for fuel), elevators to lift it into the elevated screens and separate it into the different sizes, and the bins into which the sand and rock pass after screening; there are three kettles, heated by coal and staves of the barrels that contained bitulithic cement, in which the bitulithic cement is heated, a weighing machine having a scale of seven beams, and weighing platform, buckets and mixing boxes.

The crushed rock and sand are separately piled near the end of the rotary drum. A two-horse scraper was used to bring the rock and sand to the elevators, where they are shoveled into the elevators which empty into the heating drum. It takes about four minutes from the time the aggregate starts in the drum to reach the bin. The rock is heated from 240 to 250° F. After leaving the drum the aggregate is lifted onto the screens which separate it into four sizes, passing into as many bins.

No. 1 bin contains aggregate passing No. 10 mesh; No. 2 bin contains aggregate passing ¼-in. screen and retained on a No. 10; No. 3 bin passing ½-in. screen and retained on ¼-in.; No. 4 bin passing 1¼-in. square opening and retained on ½-in. screen.

The following proportions were generally used, though some little variation was made to fit different material: 315 lb. No. 1 bin; 90 lb. No. 2 bin; 140 lb. No. 3 bin; 440 lb. No. 4 bin; and 15 lb. of dust finer than 200 mesh. This made 1,000 lb. of aggregate, to which was added 88 lb. of bitulithic cement heated to 250° F.

These materials were carefully weighed, passed into a twin pug mill and thoroughly mixed for about 1 min. 40 sec., and then dumped into a wagon which stands underneath to receive it. It is hauled by teams and dumped onto the street, shoveled over until it is about the thickness required, raked and got as near a smooth surface as possible. It is then rolled with a 10-ton roller until thoroughly smooth and no appreciable compression appears and it does not creep under the roller. If any low places develop, a little more material is put on to bring it to the required grade and thickness. After it is rolled, a squeegee car is used to spread the bitulithic cement, which is heated in kettles on the street, and the top is thoroughly coated with the bitulithic cement, using approximately ¼-gal. per sq.yd., and then covered with hot screenings from No. 1 bin with a little excess sand and put on by a sand-spreading machine using approximately 25-lb. per sq.yd. The pavement is then thoroughly rolled with a 10-ton roller, which completes the process.

FIG. 2. ALDERTON-ORTING BITULITHIC ROAD, TACOMA, WASH.

The force required at the plant and the wages paid are as follows:

1 superintendent, furnished by the patentees	$200.00 per month
4 feeders, 3 using shovels and 1 a hoe, to feed the aggregate into the elevators	2.50 per day
1 foreman	100.00 per month
1 drum fireman	2.50 per day
1 boiler man	2.50 per day
1 hopper man	2.50 per day
1 mixer man	2.50 per day
1 team	5.00 per day
1 night watchman	3.00 per day

From 3 to 13 teams costing $5 per day were used to haul the material onto the pavement.

The street force was as follows:

1 foreman	$4.00 per day
1 roller man	3.50 per day
1 man, cleaning pavement	2.25 per day
1 wagon dumper	2.50 per day
1 tamper	2.50 per day
5 shovelers	2.50 per day
2 rakers	2.50 per day
2 squeegee men	2.50 per day

Development of Inland Ocean Port at Houston, Tex.

The entrance of Houston, Tex., into the ranks of the seaports of the United States dates from the completion of the Houston ship channel in the fall of 1914. The channel has an average depth of 26½ ft. from Bolivar Roads, opposite Galveston, to the turning basin within the city limits of Houston, a distance of 50 mi. This channel was excavated from 1912 to 1914 at a cost of $2,500,000, half of which was contributed by the County of Harris, which includes Houston, and half by the United States Government. Previous to that time an 18½-ft. channel had been excavated by the Government. A complete account of this work will be found in *Engineering News*, July 23, 1914, p. 188, in an article by Charles Crotty, United States Superintendent of Dredging.

The ship channel follows Buffalo Bayou, the use of which for light-draft boats dates back many years. The excavation of the channel has involved the dredging of 35,000,000 cu.yd. at an average cost of 6⅔c. per cubic yard. For maintaining and ultimately widening the channel the County of Harris also contributed $200,000 of the $400,000 required to build and equip two thoroughly uptodate 20-in. suction dredges. The United States agreed to pay for the maintenance and operation of the dredges.

The great storm of August, 1915, which caused so much damage in Galveston, shoaled the Houston ship channel in one or two places, so that its minimum width at the present time is 100 ft. at one place. The storm also sank one of the dredges, which, however, has been floated and is now undergoing the necessary repairs at the yards of the Bowers Southern Dredging Co., Galveston, builder of the two dredges. The port authorities of Houston hope ultimately to have a channel 250 ft. wide with a minimum depth of 35 ft.

Beginnings of the Port Work

The City of Houston took up the development of the municipal port soon after the completion of the ship channel. A bond issue of $3,000,000 was voted and sold. The construction of wharf and docking facilities was at once commenced under the supervision of E. E. Sands, City Engineer, who is ex-officio consulting engineer of the harbor commission. To Feb. 1, 1916, about $1,100,000 of the $3,000,000 had been expended, and contracts for the expenditure of about $1,000,000 were about to be let.

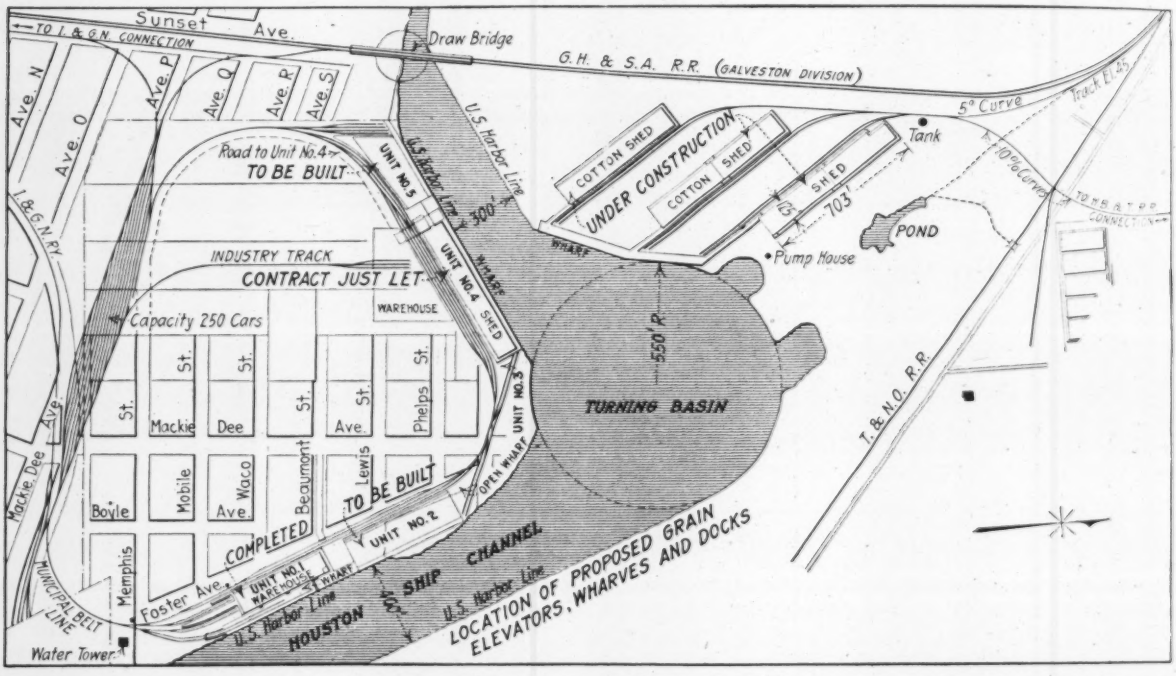


FIG. 1. GENERAL PLAN OF THE PORT OF HOUSTON, TEX., SHOWING COMPLETED AND PROJECTED DEVELOPMENTS

A general plan of completed and contemplated improvements is shown in Fig. 1. The work already finished includes shed and wharf No. 1. The wharf is a creosoted-pile and timber structure 625x50 ft. in plan and is located in front of a one-story concrete warehouse 425x100 ft. in plan and additional wooden sheds, rail connections and unloading platforms. This unit has cost $285,442. Fig. 3 is a view of it on the day it was put in service.

In constructing unit 1 all excavation above the level of the floor was considered and paid for as excavation. All excavation below the floor was considered in the contract as a part of the cost of the shed or wharf. The excavated material was used for filling, as directed by the city engineer. The concrete in the foundations was mixed 1:3:6; and in the walls and columns of the warehouse,

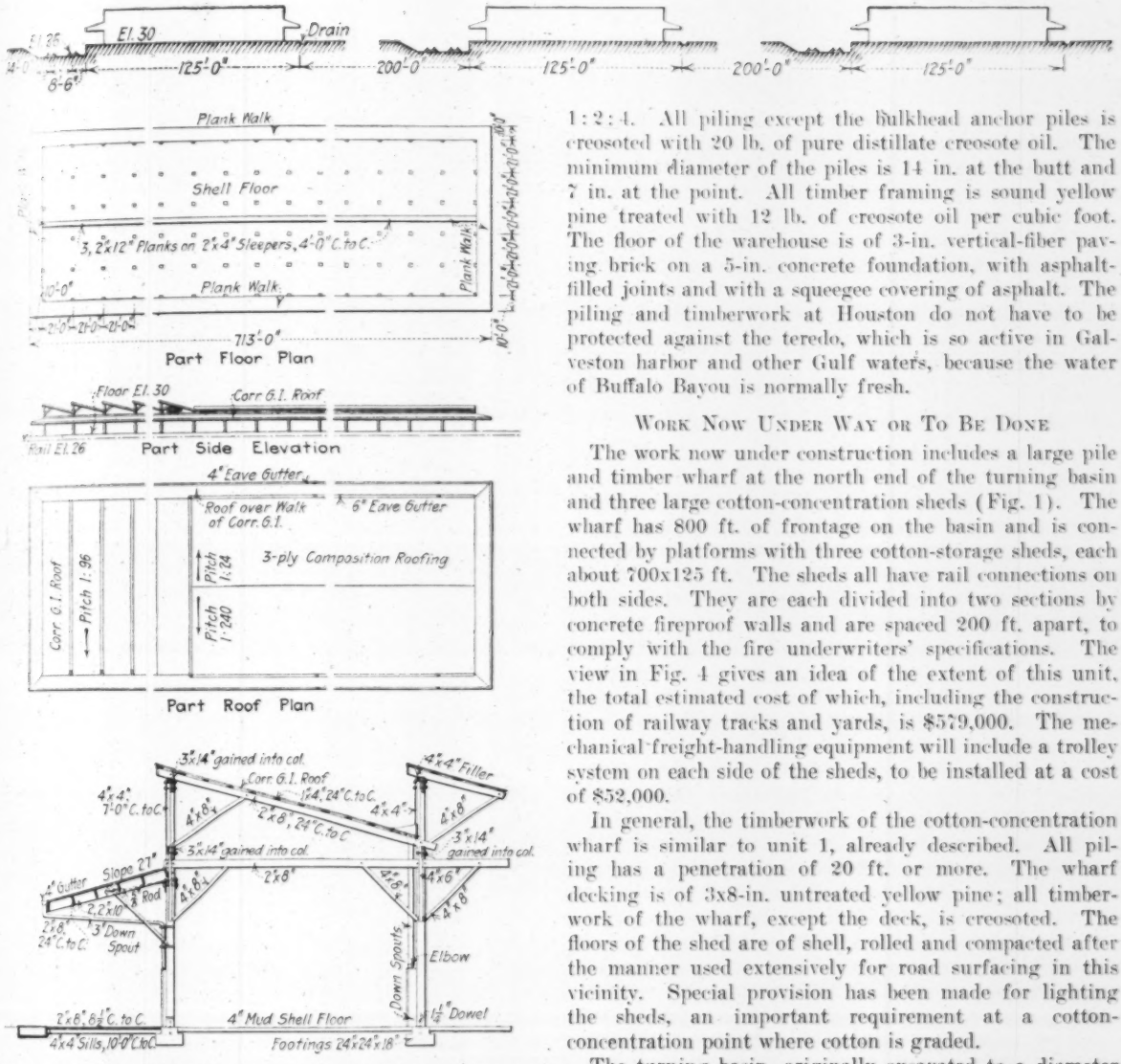


FIG. 2. DETAILS OF COTTON CONCENTRATION WHARF AND SHEDS; HOUSTON, TEX., PORT DEVELOPMENT

1:2:4. All piling except the bulkhead anchor piles is creosoted with 20 lb. of pure distillate creosote oil. The minimum diameter of the piles is 14 in. at the butt and 7 in. at the point. All timber framing is sound yellow pine treated with 12 lb. of creosote oil per cubic foot. The floor of the warehouse is of 3-in. vertical-fiber paving brick on a 5-in. concrete foundation, with asphalt-filled joints and with a squeegee covering of asphalt. The piling and timberwork at Houston do not have to be protected against the teredo, which is so active in Galveston harbor and other Gulf waters, because the water of Buffalo Bayou is normally fresh.

Work Now Under Way or To Be Done

The work now under construction includes a large pile and timber wharf at the north end of the turning basin and three large cotton-concentration sheds (Fig. 1). The wharf has 800 ft. of frontage on the basin and is connected by platforms with three cotton-storage sheds, each about 700x125 ft. The sheds all have rail connections on both sides. They are each divided into two sections by concrete fireproof walls and are spaced 200 ft. apart, to comply with the fire underwriters' specifications. The view in Fig. 4 gives an idea of the extent of this unit, the total estimated cost of which, including the construction of railway tracks and yards, is $579,000. The mechanical freight-handling equipment will include a trolley system on each side of the sheds, to be installed at a cost of $52,000.

In general, the timberwork of the cotton-concentration wharf is similar to unit 1, already described. All piling has a penetration of 20 ft. or more. The wharf decking is of 3x8-in. untreated yellow pine; all timberwork of the wharf, except the deck, is creosoted. The floors of the shed are of shell, rolled and compacted after the manner used extensively for road surfacing in this vicinity. Special provision has been made for lighting the sheds, an important requirement at a cotton-concentration point where cotton is graded.

The turning basin, originally excavated to a diameter of 600 ft., is being widened to a diameter of 1,100 ft.

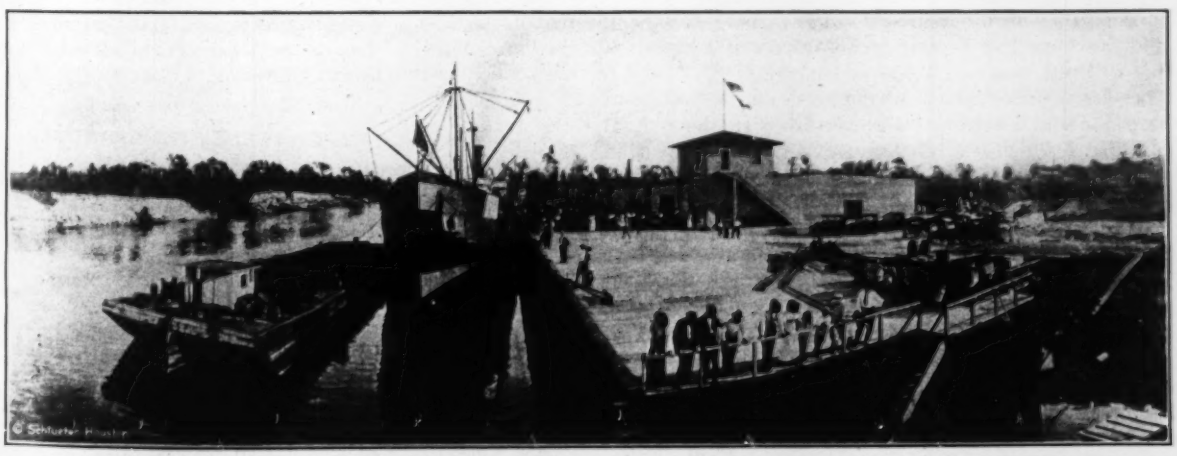


FIG. 3. UNIT NO. 1 IN THE MUNICIPAL DEVELOPMENT OF THE PORT OF HOUSTON ON THE OPENING DAY, SEPT. 26, 1915

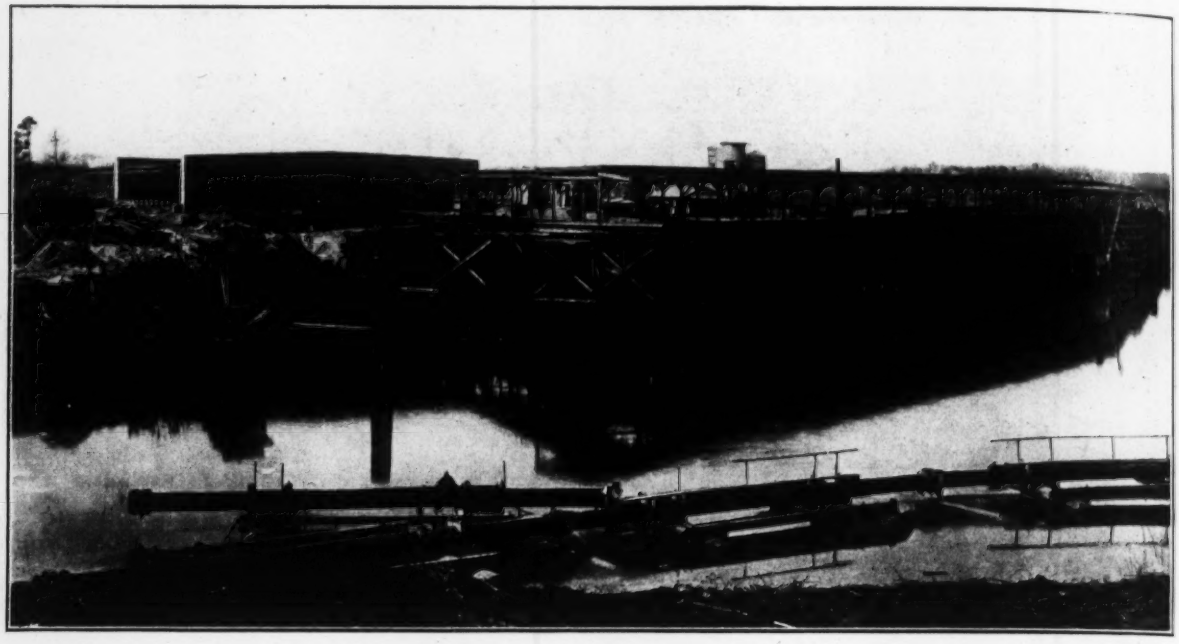


FIG. 4. COTTON-CONCENTRATION WHARF AND END OF ONE SHED, SHOWING CONCRETE FIREPROOF WALLS

This work is under contract with the Atlantic, Gulf & Pacific Co., working with the 20-in. suction dredge "Texas." This dredge, while working in the channel below Houston, made the remarkable record of 1,260,000 cu.yd. in one month. An idea of the amount of excavation required for this basin may be had when it is realized that the banks of the basin are some 20 to 30 ft. above the water level. The city already owns 237 acres of land fronting the basin and channel, and the purchase of additional land is contemplated.

The work for which contracts have just been let, as announced last week, is designated on the general plan as unit No. 4. It consists of a 777x20-ft. concrete wharf (resting on timber piles cut off below water surface) and a reinforced-concrete shed 660x100 ft., with a large warehouse in the rear. The construction of the belt-line railway to serve units 1, 2, 3 and 4 is included in this development, together with a railway-car storage yard with a capacity to handle 500 cars. The estimated cost of this unit is $579,000, not including the excavation for wharves Nos. 2 and 3, which will be necessarily done at the same time in order to widen the turning basin and build the connecting railway tracks from unit 1 to unit 4. This will cost about $112,000 additional.

Besides the development of the south and west sides of the channel and turning basin as shown in the general plan, Fig. 1, which is all included under the original bond issue, it is proposed to build at once, opposite unit 1, the first section of a large grain elevator, workhouse, track sheds, driers and loading-conveyor galleries at a cost of $731,000. The proposed unit of the grain elevator will have an initial capacity of 780,000 bu.; and the workhouse, 230,000 bu. These structures will stand some distance from, and higher than, the channel and will be connected with the wharf by housed belt conveyors. The ultimate development on this side of the channel, for which the city has already purchased the land, includes three wharves and warehouses and a railway yard for 2,500 cars. To construct one unit and a yard for 800 cars will require $920,000. This part will be built first.

All the developments thus far described will be owned and operated by the City of Houston. The belt-line railway and all the railway yards and wharf connections will be operated as a municipal enterprise. It is proposed to establish zones of uniform charges for transportation from all points within the city. The municipal railway has connections with all the city railway systems, which, counting as distinct the separate division of the same railway, number seventeen. Houston is already one of the largest concentration and shipping points for cotton. The cotton shipments already amount to approximately 3,000,000 bales annually.

Besides the municipal harbor development a private enterprise has on foot a scheme for developing the channel of Buffalo Bayou above the turning basin and nearer the city at a total estimated cost of about $10,000,000.

Houston business men have become very optimistic concerning the opportunities of Houston as a seaport; and if all the schemes now projected are carried out, Houston will doubtless become the principal Gulf port. A very essential part of the program, however, will be the widening of the 50-mi. channel to the sea. Needless to say, the development of Houston as a port is not looked upon with much enthusiasm in Galveston.

Texas Sewage-Works Activity

More sewage-works are likely to be constructed in Texas in 1916 than in any five years heretofore, according to V. M. Ehlers, State Sanitary Engineer, Austin, Tex. Much of this activity is due to the law for preventing the pollution of watercourses, passed by the state legislature in 1913 and amended in 1915. This law virtually prohibits the discharge of untreated sewage into any stream or other water of the state, except tidal water, after Jan. 1, 1917. Even tidal waters were included in the prohibition until the amendment of 1915. The body of the law is as follows:

Sec. 1. That it shall be unlawful for any person, firm or corporation, private or municipal, to pollute any watercourse or other public body of water from which water is taken for

the uses of farm, live-stock, drinking and domestic purposes, in the State of Texas, by the discharge, directly or indirectly, of any sewage or unclean water or unclean or polluting matter or thing therein, or in such proximity thereto as that it will probably reach and pollute the waters of such watercourse or other public body of water from which water is taken, for the uses of farm, live-stock, drinking and domestic purposes; provided, however, that the provisions of this bill shall not affect any municipal corporation situated on tidewater; that is to say, where the tide ebbs and flows in such watercourse. A violation of this provision shall be punished by a fine of not less than $100 and not more than $1,000. When the offense shall have been committed by a firm, partnership or association, each member thereof who has knowledge of the commission of such offense shall be held guilty. When committed by a private corporation, the officers and members of the board of directors having knowledge of the commission of such offense shall each be deemed guilty; and when by a municipal corporation, the mayor and each member of the board of aldermen or commission having knowledge of the commission of such offense, as the case may be, shall be held guilty as representatives of the municipality; and each person so indicated as above shall be subject to the punishment provided hereinbefore; provided, however, that the payment of the fine by one of the persons so named shall be a satisfaction of the penalty as against his associates for the offenses for which he may have been convicted; provided, the provisions of this act shall not apply to any place or premises located without the limits of an incorporated town or city, nor to manufacturing plants whose affluents contain no organic matter that will putrefy, or any poisonous compounds, or any bacteria dangerous to public health or destructive of the fish life of streams or other public bodies of water.

Sec. 2. Upon the conviction of any person under Sec. 1 of this act, it shall be the duty of the court, or judge of the court, in which such conviction is had, to issue a writ of injunction, enjoining and restraining the person or persons or corporation responsible for such pollution, from a further continuance of such pollution; and for a violation of such injunction, the said court and the judge thereof shall have the power of fine and imprisonment, as for contempt of court, within the limits prescribed by law in other cases; provided, that this remedy by injunction and punishment for violation thereof shall be cumulative of the penalty fixed by Sec. 1 of this act; and the assessment of a fine for contempt shall be no bar to a prosecution under Sec. 1; neither shall a conviction and payment of fine under Sec. 1 be a bar to contempt proceedings under this section.

Sec. 3. Any city or town of this state, with a population of more than 50,000 inhabitants, which has already an established sewerage system dependent upon any watercourse or other public body of water, from which water is taken for the uses of farm, live-stock, drinking and domestic purposes, or which discharges into any watercourse or public body of water, from which water is taken for the uses of farm, live-stock, drinking and domestic purposes, shall have until Jan. 1, 1917, within which to make other provisions for such sewage. Cities and towns of less population than 50,000 inhabitants shall have until Jan. 1, 1917, within which to make other arrangements for the disposal of such sewage. Any person, firm or corporation, private or municipal, coming under or affected by the terms of this bill, or any independent contractor having the disposal of the sewage of any city or town, shall have until Jan. 1, 1917, within which to make other arrangements for the disposal of such sewage, or other matter which may pollute the water, as defined in this bill.

Sec. 4. The Texas State Board of Health is authorized, and it is hereby made its duty, to enforce the provisions of this act; and to this end the Governor shall appoint, by and with the consent of the Senate, an inspector to act under the direction of the said Board of Health and the state health officer making such investigations, inspections and reports, and performing such other duties in respect to the enforcement of this act as the said Board of Health officer may require.

It is claimed that there are some loopholes in the law, and its constitutionality is being freely questioned. It makes no provision for financing the work, and under the laws of the state governing the issue and sale of municipal bonds it has frequently been practically impossible to inaugurate much needed public improvement. It would seem doubtful under the circumstances if a mayor or city commissioner could be held responsible if the public would not or could not finance the work. The law specifically states that the issuing of the injunction must succeed the conviction of the officers, so if it turns out to be impossible to convict the officers the law would seem to be of no effect.

Notwithstanding the doubtful character of the law there is evidence that nearly all the municipalities of the state are willing to comply with its spirit. To comply with the letter of it would of course entail the purification of sewage to the degree required for a water-supply. Such an interpretation will not be made by the state officials. Mr. Ehlers says:

> In enforcing the stream-pollution act the economic aspect of the case will be considered; namely, the results accomplished must be reasonably commensurate with the cost of prevention of pollution. In other words, the State Board of Health places a liberal interpretation upon the word pollution in the act. Our work up to the present time has been more or less along educational lines. Where a water-supply becomes suspicious, we advise treating the water.

Mr. Ehlers has issued a preliminary report on "Standards of Purity of Sewage Effluents," in which is stated as the object "to arrive at some temporary standard or working basis." After defining pollution and the tests by which pollution is to be determined, the report closes with the following summary:

> Whereas, it is inevitable that absolute prevention of pollution is impossible, that this state has no control over the Canadian, Pecos, Rio Grande and Red Rivers outside of the state boundary, and recognizing the process of self-purification of streams, it would be needless expense to require all municipalities to purify their sewage to a drinking-water standard. It is recommended that with minor changes the standards from the report of the Committee on Standards of Purity . . . [of the National Association for Preventing the Pollution of Rivers and Waterways, see "Engineering News," Oct. 31, 1913] be adopted as a working basis for the future.

Of the four largest cities in the state, San Antonio disposes of its sewage by irrigation, Dallas has under construction an Imhoff-tank disposal plant, Houston is getting ready to install an activated-sludge plant and Fort Worth has taken no definite steps toward the construction of a plant. Of the 130 cities and towns in Texas having sewer systems, all but two, Mr. Ehlers states, have shown an inclination to build disposal works. A score or more already have works under way. The capital city of Austin has had surveys and recommendations made, but no definite steps have been taken. The City of Waco, which discharges its raw sewage into the Brazos River, has shown a disposition to contest the law.

The consulting service of the State Sanitary Engineer is free to any municipality requesting it. During his first three months of office specific information was given by him in answer to about fifty requests of this kind. All designs for sewerage systems and dispoal works must be passed upon by him.

A great deal of the sewer-designing work of Texas municipalities has been and is at present being done by firms of consulting engineers, both in and outside the state. Competition for much of this work is very keen and appears not to be governed by any existing code of engineering ethics. One effect of the new law will be to protect the towns and cities from the designs of pseudo and incompetent engineers, as has been already accomplished in Kansas under a similar but less drastic law.

There seems to be no doubt that the law will serve—in fact, already has served—a useful purpose. Mr. Ehlers states that while the law is far from being a model, "it is gratifying to know that it has caused an awakening of the public toward better sanitation; municipalities are not only submitting plans for sewage-treatment works, but are anxious for advice on sanitation problems."

Diagram for Full Comparison of Hydraulic Turbines

By Robert E. Horton* and Walter C. Pomeroy†

SYNOPSIS—A new form of efficiency-contour diagram is developed, using proportionate speeds and powers, referred to speed and power at maximum efficiency, instead of absolute quantities, as has been customary. When unity speed is taken as the "type characteristic" of a runner under study (speed at which a model runner would develop 1 hp. under 1-ft. head), the diagram approximately applies to all sizes of runners having identical features.

With a view to devising a graphical means whereby the suitability of different hydraulic turbine runners to meet given requirements can be deduced, the writers have developed the type of efficiency diagram presented in the following paragraphs and accompanying curves. Somewhat similar methods are in general use now, although

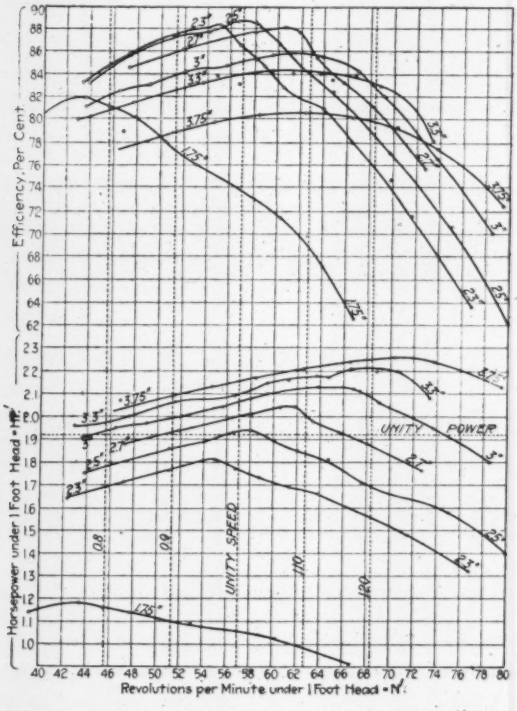


FIG. 1. SIMPLE POWER-SPEED AND EFFICIENCY-SPEED CURVES

For 23-in. right-hand hydraulic turbine runner built by Hydraulic Turbine Corporation; Holyoke test 2,426, Dec. 1, 1915

it must be said that so far no single one has been generally accepted. In the type of diagram here presented the ratios of various speeds and powers to the speed and power for maximum efficiency are utilized instead of absolute quantities. The diagrams have a further usefulness; by making the unity power 1 hp. under 1-ft. head the unity speed corresponds to the "type characteristic" of the runner at its best efficiency points.

This type of diagram shows the efficiency at which a turbine could operate when running at various proportionate speeds and when producing various percentages of unity power (unity power being capacity at maximum efficiency). The diagram will be made to show at what proportionate speed the turbine would have to operate

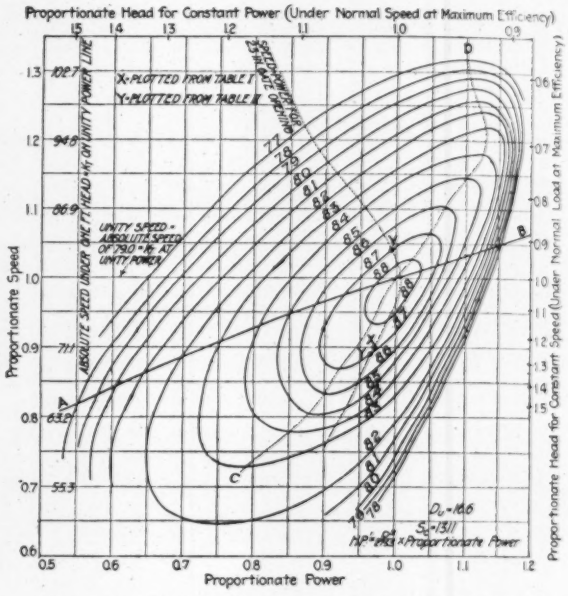

Proportionate Head for Constant Power (Under Normal Speed at Maximum Efficiency)
Proportionate Speed
Proportionate Power
Proportionate Head for Constant Speed (Under Normal Load at Maximum Efficiency)
X-PLOTTED FROM TABLE I
Y-PLOTTED FROM TABLE II
UNITY POWER LINE
UNITY SPEED = ABSOLUTE SPEED OF 750 RPM AT UNITY POWER
ABSOLUTE SPEED UNDER ONE FT. HEAD = 51.3% OF UNITY SPEED
SPECIFICATION OPENING
HP = 66.3 x Proportionate Power

FIG. 2. EFFICIENCY-SURFACE DIAGRAM FOR PROPORTIONATE SPEEDS AND POWERS

Showing one of the typical speed-power-gate curves used in developing the constant-efficiency contours. For 23-in. runner of Holyoke test 2,426

to maintain a constant speed under different heads and also to show the efficiency which would be developed for any given actual power output under the various heads. Moreover, it will serve as an absolute and final comparison between runners of different type characteristics, and by the introduction of proper constants any possible combination of power, speed and diameter suiting a particular runner design can be worked out. These uses will be shown by examples.

Development of Diagram

The development of the new type of efficiency surface diagram is illustrated by employing Holyoke test data from a 23-in. and a 30-in. runner built by the Hydraulic Turbine Corporation. First of all, the ordinary power-speed and efficiency-speed curves are plotted by reducing the Holyoke data to a constant head of 1 ft. These curves are shown in Fig. 1. On this chart will be seen the unity-speed and unity-power lines (which pass through the point of maximum efficiency) and a few of the proportionate-speed lines that form the basis of the final diagram.

Reading along the proportionate-speed line 0.90 (absolute speed $N' = 51.3$), the absolute power and effi-

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†Hydraulic Engineer, Hydraulic Turbine Corporation, Camden, N. Y.

ciency at the various gate openings may be tabulated, as shown in Table 1. In the fourth column of this table is the ratio absolute power (column 2) to power at point of maximum efficiency. Such a table is made for each proportionate-speed line. Plotting the values in column 4 of Table 1 (for line 0.90) on the abscissa for a proportionate speed of 0.90 in Fig. 2, we arrive at one point on the speed-power curves for each gate opening; the other tables, not here given, supply the remaining points for the curves, one of which is shown complete (for 2.5-in. gate opening).

Next, the values of efficiency in column 3, Table 1, are plotted against proportionate speed, as shown by Fig. 3 (along line 0.90 for this table), giving a speed-efficiency curve for each gate opening. Tabulating the values of the proportionate-speed points at which each constant-efficiency ordinate cuts the various gate-opening curves of Fig. 3, we secure Table 2 (though this table is really unnecessary in practice) for each efficiency contour desired on Fig. 2; and from Table 2 we determine a constant-efficiency point on each speed-power-gate curve on Fig. 2, these points determining the constant-efficiency surface.

It is readily seen that Fig. 2 is plotted in such a manner as to show the efficiency at which a turbine could operate when running at various relative speeds, expressed in terms of the speed of the maximum efficiency as unity, and when producing different amounts of power, expressed in terms of the horsepower at maximum efficiency as unity. For example, if owing to backwater conditions, the head is reduced so that in order to operate at constant speed it is necessary to run the turbine at a speed 10% greater than the speed of greatest efficiency, then the diagram shows that, when operating at normal power under the reduced head, the efficiency would be about 85%.

TABLE 1. ABSOLUTE HORSEPOWER UNDER 1-FT. HEAD, EFFICIENCY AND PROPORTIONAL HORSEPOWER; AT PROPORTIONATE SPEED 0.9 OF 23-IN. RUNNER, HOLYOKE TEST 2,426

Gate Opening, In.	Absolute Hp.'	Efficiency	Proportionate, Hp.
1.75	1.1	77.2	0.573
2.3	1.77	87.6	0.921
2.5	1.86	87.3	0.969*
2.7	1.93	86.0	1.005
3.0	1.99	84.0	1.036
3.3	2.06	82.5	1.072
3.75	2.09	79.0	1.09

* See Fig. 2.

TABLE 2. PROPORTIONATE SPEED POINTS; AT WHICH THE EFFICIENCY LINE 87% CUT THE GATE-OPENING CURVES IN FIG. 3

Gate Opening, In.	Prop. Speed	Prop. Speed
1.75	.....	.....
2.3	0.870	0.970
2.5	0.887	1.042*
2.7	0.955	1.065
3.0	.....	.....
3.3	.....	.....
3.75	.....	.....

* See Fig. 2.

TABLE 3. PROPORTIONATE SPEED AND POWER FOR CONSTANT SPEED OR CONSTANT POWER FROM A HYDRAULIC-TURBINE RUNNER OPERATING UNDER VARYING HEAD

Ratio Actual to Normal Head, $\frac{H_2}{H_1}$	Proportionate Speed for Constant Speed	Proportionate Power for Constant Power
0.50	1.4242	2.828
0.60	1.2923	2.151
0.70	1.196	1.707
0.80	1.118	1.398
0.90	1.054	1.171
1.00	1.0	1.0
1.10	0.9534	0.8665
1.20	0.91285	0.7610
1.30	0.8769	0.6748
1.40	0.84498	0.6039
1.50	0.81670	0.5444

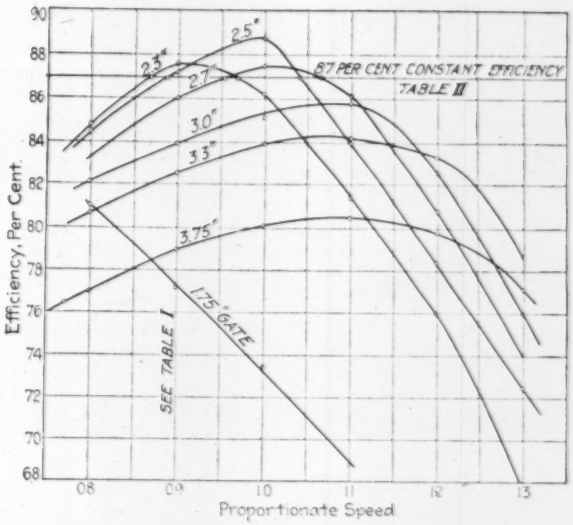

FIG. 3. PROPORTIONATE SPEED AND EFFICIENCY CURVES ACCOMPANYING FIGS. 1 AND 2

The diagramdoes not show directly, however, at what proportionate speed the turbine would have to run to maintain constant speed under different heads, nor does it show directly what the efficiency would be for any given actual power output under different heads. In order to determine these data from such a diagram in the simplest manner possible, two additional scales may be added to the figure—one for head corresponding to different relative speeds, the other giving the power corresponding to different relative heads. These scales are derived in the following manner:

Since the speed of a turbine operating at a given efficiency under any head is proportional to the square root of the head, it is evident that, if a turbine is set to operate at some particular speed, say, for example, its speed of maximum efficiency under a stated head, this speed being taken as unity, then in order to maintain this speed at either a greater or a less head it must under the changed conditions operate at a speed less or greater than the normal speed for the changed head and inversely proportional to the square root of the ratio of the original head to the changed head. Similarly, since the horsepower of a turbine varies as the three-halves power of the head, it is evident that to produce constant power out-

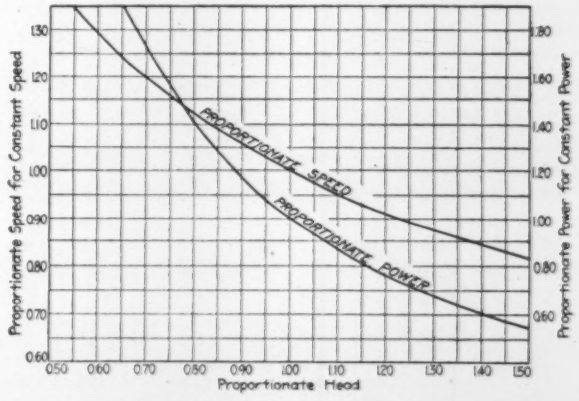

FIG. 4. PROPORTIONATE SPEEDS AND POWERS FOR CONSTANT SPEED OF POWER UNDER VARYING HEADS

put under different heads the power (constant) under the changed head must be inversely proportional to the three-halves power of the ratio of original to changed head.

The ratios, showing the proportionate speed at which a turbine must run in order to operate at constant speed under varying head, are shown in column 2 of Table 3 and graphically in Fig. 4, which is useful for finding intermediate points. Similarly, the proportionate power that the turbine must produce in order to produce a constant power output under different heads is shown in column 3 of the table and in Fig. 4, column 1 being in each case the ratio of the changed head to the standard or original head, which is taken as unity. Plotting the values given in columns 1 and 2 of Table 3 alongside of the scale of proportionate speeds on Fig. 2, the scale showing proportionate heads is obtained. Similarly, plotting the data from columns 1 and 3 alongside of the scale of proportionate power, the scale showing proportionate head for constant power is obtained. It is now possible with the aid of these additional scales to read from the efficiency-surface diagram directly the efficiency and power that can be obtained when the turbine is under varying heads, as under backwater conditions.

Since the speed varies as the square root and the power varies as the three-halves power of the head, it is evident that a certain change in head produces different changes in the relative speed and relative power respectively. Since the efficiency is constant, as a rule, only when the turbine is operating at a certain relative speed and power, it is evident that, in general, constant efficiency cannot be obtained when a turbine operates under a varying head. The question arises, What efficiency can be obtained from a turbine operating at constant speed and producing constant power output under varying head?

This is easily determined from the diagram. For this purpose plot a line AB on the diagram running through points corresponding to the same proportionate heads on the speed and power scales respectively. This line will pass through the point chosen as the point of normal power and speed—that is, the point O, or point of maximum efficiency in this case. The line AB intersects the contours of efficiency at points corresponding to certain proportionate heads for constant power and constant speed, and the efficiencies at these points of intersection are those which could be obtained with a turbine operating at constant power and speed under the corresponding relative heads.

Use in Selection of Turbines

If it is required that the turbine shall operate at constant speed under varying heads, but if a constant power output is not required, higher efficiencies may be obtained than under conditions of both constant power and constant speed. The line CD on the diagram is drawn through the maximum efficiencies that could be obtained with a turbine operating at constant speed under the proportionate heads indicated on the scale of speeds at the right of the diagram for normal speed at the point of maximum efficiency.

It is generally true that, having given a turbine of a certain size, which has a certain K_t, or, in other words, a certain maximum absolute efficiency and certain speed and power under 1-ft. head, another turbine of larger or smaller diameter of identical features and proportionate dimensions will have substantially the same efficiency and K_t, so that with a diagram of this form the availability of a turbine of the right size to meet certain conditions can be determined with regard to those conditions from a test of a similar turbine of larger or smaller size. (At least this method seems to give the best working hypothesis in cases where a turbine of the actual size required for a particular case has not been tested. It is well known of course that the efficiency rises slightly as the size of the turbine is increased.)

The power and speed under 1-ft. head at best efficiency of the 23-in. runner used for illustration here have been shown on Fig. 1 to be $HP.' = 1.92$ $N' = 57$ respectively. As already stated, the type characteristic is independent of the size, remaining a constant for the runner series. By definition it is the speed at which a turbine would run under 1-ft. head if it was so reduced or enlarged in all its proportions as to give 1 hp. under 1-ft. head, or expressed numerically,

$$K_t = N' \sqrt{HP.'}$$

Thus, from the foregoing,

$$K_t = 57 \sqrt{1.92} = 79$$

Reduce the dimensions of the runner under study so that the absolute value of unity power on Fig. 2 actually will be 1 hp. under 1-ft. head instead of 1.92. Since K_t remains a constant; therefore, $79 = N'\sqrt{1}$, or the best speed (unity on Fig. 2) under 1-ft. head of the hypothetical wheel will be 79 instead of 57. As a means of comparison between runner types this diagram now shows at a glance the absolute criterion—the K_t. By its use we are comparing runners all capable of exactly the same amount of work—1 hp. under 1-ft. head. Unity power will be the same for all, and unity speed will distinguish the curve form just as readily and fully as K_t does the runner type.

It must be further noticed that the comparison is between the speed of runners, all capable of developing the same power, rather than between the power of runners at the same speed or of the same diameter. The latter comparisons appeal to our imagination, but in reality are not the logical view; in fact, a comparison based on runners of the same diameter is technically wrong.

Now, with the addition of two constants we have the basis for all ordinary computations of horsepower, speed and diameter, suiting the particular runner design. We have introduced what we are pleased to call a "unit diameter," D_u and a "speed constant," S_c. The D_u is nothing more or less than the diameter in inches of our hypothetical runner, which develops 1 hp. under 1-ft. head. The S_c is the product of D_u and K_t. By introducing these constants in the following equations we can solve for the required unknowns:

$$D = \sqrt{\frac{HP.}{H^3}}\, D_u = \frac{S_c \sqrt{H}}{R.P.M.}$$

$$R.P.M. = \frac{S_c \sqrt{H}}{D}$$

in which D = diameter, in inches, of a runner that will give $HP.$ (horsepower) at *best efficiency* under H (feet head) at $R.P.M.$ (revolutions per minute).

Before going farther into the use of these diagrams it may be wise to review the subject of "type character-

istic" or "unit speed" in the briefest possible manner. It is self-evident that with almost every conceivable combination of horsepower, head and speed to meet, there must necessarily be some very radically different designs of turbine runners. It is just as imperative that we have a ready and sure means of comparison between the many designs; also that, with given conditions at a plant, we may have some means by which we can immediately eliminate the great number of runner designs not at all suited and centralize our study on just those designs fitting our problem. Such a means of comparison between runner types and of connection between local conditions and runner designs must necessarily be based on the work which the runner can perform; that is, we must have some simple expression of runner duty which will stand out distinctly as a special characteristic of different runners and may also be expressed in terms of local plant conditions. The so-called "type characteristic" or "unit speed" is just the desired expression.

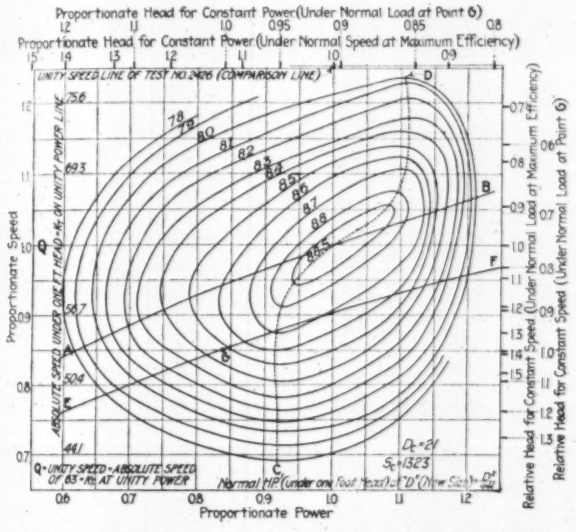
Proportionate Head for Constant Power (Under Normal Load at Point 6)
Proportionate Head for Constant Power (Under Normal Speed at Maximum Efficiency)
UNITY SPEED LINE OF TEST NO. 2426 (COMPARISON LINE)
Proportionate Speed
Proportionate Power
Relative Head for Constant Speed (Under Normal Load at Maximum Efficiency)
Relative Head for Constant Speed (Under Normal Load at Point 6)
Normal HP (under one foot head) = "D" (from Scale) = D²
Qc = 24
Sc = 323

FIG. 5. EFFICIENCY-SURFACE DIAGRAM FOR NEW MILL-TYPE TURBINE

For 30-in. right-hand runner built by Hydraulic Turbine Corporation; Holyoke test 2,267

We neglect all design details entirely, reduce all runners to the same capacity and then compare their speeds. Such a classification is based definitely on capacity and speed. The type characteristic (K_t) is the speed under 1-ft. head of a turbine runner so reduced or enlarged in all its proportions as to give 1 hp. under 1-ft. head. Expressed numerically, it is

$$K_t = \frac{R.P.M. \sqrt{HP.}}{H^{\frac{5}{4}}}$$

which is also an expression of the three controlling factors at any site—the horsepower, the revolutions per minute and the head in feet.

Revolutions per minute under 1-ft. head $= N' = \frac{R.P.M.}{H^{\frac{1}{2}}}$; horsepower under 1-ft. head $= HP.' = \frac{HP.}{H^{\frac{5}{2}}}$; and

$$K_t = \frac{R.P.M. \sqrt{HP.}}{H^{\frac{5}{4}}} = N' \sqrt{HP.'}$$

Let $HP.' = 1$; then $K_t = N'$. The K_t of a multiple runner unit is greater than that of a single runner in the ratio of the square root of the number of runners in the unit. To facilitate the calculation of K_t a table of five-fourths powers of numbers is presented herewith as Table No. 6.

Examples of Turbine Study

The uses of the diagrams of Fig. 2 may be illustrated by two examples. For the first, assume a normal head H of 20 ft. and a constant speed $R.P.M.$ of 117. A maximum capacity of 900 hp. is desired under 20-ft. head at not less than 83% efficiency. Now

$$K_t\ (maximum) = \frac{117 \sqrt{900}}{20^{\frac{5}{4}}} = 83$$

We can readily see from the diagrams that the type of runner is closely shown by test 2,426 for the normal $K_t = 79$. On Fig. 2 read along unity-speed line beyond unity power until it crosses about 83% efficiency line, which is at 1.1 proportionate power. This represents maximum power desired. Therefore, the normal power of the runner will be $90 \div 1.1 = 815$. Then

$$D = \sqrt{\frac{900}{20^{\frac{5}{2}}}} \times 16.6 = 50\ in.$$

Unity power of the 50-in. runner $= \frac{50^2}{275.5} = 9.1$; and the efficiency and power at the various heads are shown in Table 4, values being found along the line CD, Fig. 2.

For the second problem assume given a normal head of 25 ft., and required a maximum of 300 hp. under normal head and at a speed of 220 r.p.m.

$$Maximum\ K_t = \frac{220 \sqrt{300}}{25^{\frac{5}{4}}} = 68$$

This value leads us to try the runner of test 2,267, which has a normal K_t of 63.

$$D = \frac{S_c \times \sqrt{H}}{R.P.M.} = \frac{1{,}323 \times 5}{220} = 30\ in.$$

The normal $HP.'$ for a 30-in. runner is $30^2 \div 441 = 2.04$ (see Fig. 5), and $2.04 \times 25^{\frac{5}{2}} = 255$ hp. normal. The required maximum power corresponds to $300 \div 225 = 1.18$ proportionate power. The proportionate power of 1.18 on the normal-speed line gives 82% efficiency—which is a good value for full gate.

The efficiency and horsepower at the various heads are shown in Table 5 under column 3 and column 6 respectively. The values of efficiency and proportionate horse-

TABLE 4. EFFICIENCY AND HORSEPOWER OBTAINABLE UNDER VARYING HEAD, CONSTANT SPEED FOR 30-IN. RUNNER OF TEST 2,426

Head, Ft.	Proportionate Head	Efficiency at Constant Speed	Proportionate Hp. at Constant Speed	Hp.'	Actual B.Hp.
18	0.9	87.2	1.042	9.5	725
19	0.95	88.0	1.022	9.3	770
20	1.0	88.8	1.0	9.1	815
21	1.05	88.7	0.99	9.0	875
22	1.1	88.3	0.975	8.86	915
23	1.15	88.0	0.965	8.77	970
24	1.2	87.6	0.952	8.66	1,020

TABLE 5. POWER AND EFFICIENCY OF 30-IN. WHEEL OF TEST 2,267; ACCORDING TO PROBLEM 2

(1) Head, Ft.	(2) Proportionate Head	(3) Efficiency at Proportionate Constant Speed, 220 R.p.m.	(4) Hp. for Constant Speed, 220 R.p.m.	(5) Absolute Hp.'	(6) B.Hp.	(7) Efficiency for Constant R.p.m. = 220—Hp. = 255, Point O	(8) Efficiency for Constant R.p.m. = 185—Hp. = 215, Point G
20	0.80	86.2	1.11	2.26	202	....	*76.0
21	0.84	87.3	1.105	2.25	216	....	84.1
22	0.88	88.2	1.092	2.23	230	80.0	86.5
23	0.92	88.6	1.074	2.19	240	86.0	87.0
24	0.96	88.7	1.04	2.12	249	88.5	87.0
25	1.00	88.9	1.0	2.04	255	88.9	84.8
26	1.04	88.7	0.975	2.00	265	88.3	83.0
27	1.08	88.5	0.955	1.96	275	87.0	81.0
28	1.12	88.4	0.94	1.925	285	86.2	79.0
29	1.16	88.2	0.93	1.9	297	85.0	....

TABLE 6. VALUES OF $H^{\frac{3}{2}}$ FOR CALCULATING TYPE CHARACTERISTIC (ROBERT E. HORTON)

H	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
4	5.66	5.83	6.01	6.19	6.37	6.55	6.74	6.92	7.10	7.29
5	7.48	7.66	7.85	8.04	8.23	8.42	8.62	8.81	9.00	9.20
6	9.39	9.59	9.78	9.98	10.18	10.38	10.58	10.78	10.98	11.18
7	11.39	11.59	11.79	12.00	12.21	12.41	12.62	12.83	13.04	13.24
8	13.45	13.67	13.88	14.09	14.30	14.51	14.73	14.94	15.16	15.37
9	15.59	15.81	16.02	16.24	16.46	16.68	16.90	17.12	17.34	17.56
10	17.78	18.00	18.23	18.46	18.68	18.90	19.13	19.35	19.58	19.80
11	20.03	20.26	20.49	20.72	20.95	21.18	21.41	21.64	21.88	22.11
12	22.34	22.57	22.80	23.04	23.27	23.50	23.74	23.97	24.21	24.44
13	24.68	24.92	25.16	25.40	25.64	25.88	26.12	26.36	26.60	26.84
14	27.08	27.32	27.56	27.81	28.05	28.29	28.54	28.78	29.03	29.27
15	29.52	29.77	30.01	30.26	30.50	30.75	31.00	31.25	31.50	31.75
16	32.00	32.25	32.50	32.75	33.00	33.25	33.50	33.76	34.01	34.27
17	34.52	34.77	35.03	35.28	35.54	35.79	36.05	36.31	36.56	36.82
18	37.08	37.34	37.60	37.85	38.11	38.37	38.63	38.89	39.15	39.41
19	39.67	39.93	40.19	40.45	40.71	40.97	41.24	41.50	41.76	42.03

H	0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
20	42.3	45.0	47.7	50.5	53.2	55.9	58.8	61.6	64.5	67.4
30	70.2	73.2	76.2	79.2	82.2	85.2	88.2	91.3	94.4	97.5
40	100.6	103.8	107.0	109.2	112.4	116.6	119.8	123.1	126.4	129.7
50	133.0	136.3	139.6	143.0	146.3	149.6	153.0	156.5	159.9	163.4
60	166.8	170.4	173.9	177.5	181.0	184.6	188.1	191.7	195.2	198.8
70	202.3	205.9	209.6	213.2	216.9	220.5	224.2	228.0	231.7	235.5
80	239.2	243.0	246.7	250.5	254.3	258.1	261.9	265.7	269.5	273.4
90	277.2	281.1	285.0	288.8	292.7	296.6	300.5	304.4	308.4	312.3
100	316.2	320.2	329.2	328.2	232.2	336.2	340.2	344.2	348.2	352.3
110	356.3	360.3	364.4	368.4	372.5	376.5	380.6	384.7	388.8	393.0
120	397.1	401.3	405.4	409.6	413.8	418.0	422.2	426.4	430.5	434.7
130	438.9	443.2	447.4	451.7	455.9	460.2	465.5	468.7	473.0	477.2
140	481.5	485.8	490.1	494.5	498.8	503.2	507.5	511.9	516.3	520.6
150	525.0	529.4	533.7	538.1	542.5	546.8	551.3	555.8	560.2	564.7
160	569.1	573.5	578.0	582.4	586.8	591.2	595.7	600.3	604.8	609.3
170	613.9	618.4	622.9	627.4	632.0	636.5	641.1	645.6	650.2	654.8
180	659.3	663.9	668.5	673.1	677.7	682.3	486.9	491.5	496.1	500.7
190	705.3	709.9	714.6	719.2	723.9	728.5	733.2	737.9	742.6	747.3
200	752.0	....	....	....	....	....	....	....	....	....

power (column 4) are found at the points of intersection of the line *CD* of Fig. 5 with the proportionate-head values; and with the aid of Fig. 4 the intermediate values of proportionate head are found in terms of proportionate power or proportionate speed. The values of proportionate horsepower found are multipled by the value of the normal horsepower (2.04), giving the absolute *HP.'*, in column 5. Then each value of *HP.'* is multiplied by the $\frac{3}{2}$ power of its corresponding head (column 6).

Suppose this wheel is to be used in a small industrial plant that not only must have a constant speed, but also a constant power output under the varying head conditions. This, it must be understood, is a very rigid test of the wheel and calls for extreme flexibility. If we use as the constant power and speed required the value of the normal power and speed just found of 220 r.p.m. and 255 hp., then we simply read the efficiency along the line *AB* where this line crosses the proportionate-head values, again using Fig. 4 for intermediate points. These values are tabulated in column 7 and, considering the very severe requirements, show remarkable results.

If we are handicapped still further and are confronted with bad backwater conditions, we may often materially improve the situation for the lower heads by meeting a change in speed and power requirements and then "undergating" the wheel. In this matter we simply increase the overload capacity of the wheel, usually at a slight expense of maximum efficiency.

Take our present example: Let us use the speed and power corresponding to point *G* on the diagram as the constant values. *G* is at proportionate speed of 0.85 and proportionate power of 0.84. We then have a constant speed of 185 instead of 220 and a constant power of 215 instead of 225. And now reading along the line *EF* (drawn as was *AB* after shifting the proportionate-head scales so that 1 coincides with 0.84 and 0.85 old speed and power points) as before, along *AB*, the efficiency values are found as given in column 8 of Table 5. We still have a wheel capable of giving the 300-hp. maximum under normal head, but at the accepted reduced speed of 185 and an efficiency of about 76%.

Machines for Building Levees*

By J. R. Slattery†

SYNOPSIS—Great amount of Mississippi levee work made it imperative that machines be developed to take place of old man-and-mule methods. Description and costs of three types of machines.

The several floods of 1912 and 1913 in the Mississippi River resulted in a number of crevasses, which it was imperative to close prior to the time the next high water was to be expected. There was consequently placed on the market a large amount of emergency work—more than the contractors then in business on the river could handle. The result was that prices soared, until in 1913 the average price of levee work let by contract was 23.39c. in the Fourth District, 25.59c. in the First and Second Districts and 36.01c. in the Third District.[1] The average contract price of work in the Lower Yazoo District during previous years is shown by Table 1.

Recognizing the inability of existing team outfits on the river to handle economically the levee work made necessary by the great floods of 1912 and 1913, the Mississippi River Commission on Apr. 21, 1913, directed the district officers to give careful consideration to the possibility of using suitable mechanical appliances, either hired or purchased, with a view to securing a large output and a substantial gain in economy, and again on Nov. 21, 1915, directed the district officers "to make diligent inquiry into and study of the possibility of developing and acquiring suitable mechanical devices for use in the economical construction of efficient levees, with a view to their adoption."

TABLE 1. AMOUNT AND UNIT COSTS OF MISSISSIPPI RIVER LEVEES

Fiscal Year	Total Cu.Yd. Placed	Average Price per Cu.Yd., Cents	Fiscal Year	Total Cu.Yd. Placed	Average Price per Cu.Yd., Cents
1882–90	1,672,619	28.83	1902–3	841,589	17.21
1891–92	979,154	22.37	1903–4	1,905,842	17.24
1892–93	793,365	21.12	1904–5	1,040,708	17.40
1893–94	785,642	17.50	1905–6	429,632	19.75
1894–95	1,326,255	11.19	1906–7	305,507	21.89
1895–96	1,149,411	9.26	1907–8	918,504	20.55
1896–97	256,153	11.70	1908–9	986,674	25.31
1897–98	4,141,326	12.67	1909–10	303,878	22.08
1898–99	2,845,342	11.67	1910–11	906,761	20.34
1899–1900	1,840,340	17.30	1911–12	420,260	11.64
1900–1901	614,940	13.52	1912–13	1,072,305	25.80
1901–2	21,932	18.56			

*From "Professional Memoirs," Corps of Engineers, United States Army and Engineer Department at Large, May-June, 1916.

†Major, Corps of Engineers, United States Army, Vicksburg, Miss.

[1]The Mississippi River Commission is engaged in, among other things, the construction, extension and repair of levees from Cape Girardeau, Mo., to the Head of the Passes. The stretch of river is divided, for the execution of levee and other work, into four districts. The First District extends from Cape Girardeau to the foot of Island 40 (270 mi.); the Second from the foot of Island 40 to the mouth of White River (173 mi.); the Third thence to Warrenton, Miss. (214 mi.); the Fourth thence to the Head of the Passes, about 13 mi. from the Gulf of Mexico (453 mi.).

The standard specifications for levee construction provide as follows in regard to the borrow pits from which the material for the construction of levees is to be obtained:

BORROW PITS

For Levees Above Red River—Unless directions are given otherwise by the contracting officer, all earth must be procured from the river side of the levee. The location of borrow pits, whether on river side or land side of the levee, will be determined by the contracting officer for each section of the work advertised, and will be a part of the information furnished prospective bidders. When shown on maps or profiles submitted to bidders that earth cannot be obtained opposite stations, it must be hauled from places designated without extra compensation. In no case shall material be obtained within 40 ft. of the base of the levee on the river side or within 100 ft. on the land side. The side slope of the pit next to the embankment must not be steeper than 1 on 2 down to a depth of 3 ft.; from that point outward the pit may be deepened with a slope of 1 on 50 when on the river side of the levee and 1 on 100 when on the land side. On enlargement work no material will be taken from the old pits without special permission of the contracting officer, in which case the old pits that are not already down to the above specified limits below the original natural surface of the ground may be deepened accordingly; but in any case the material must be excavated and removed in such manner as will afford thorough drainage to the back of the pit and disfigure the land as little as possible. Any material taken below the specified depth must be replaced, and any borrow outside the limits of the pits as defined herein shall, unless direction has been given for such borrow by the contracting officer, be promptly replaced, or the same will be measured and the yardage deducted from the next estimate.

For Levées Below Red River—The same as above, except that in no case shall material be obtained within 20 ft. of the base of the levee on the river side or within 80 ft. on the land side. The side slope of the pit next to the embankment must not be steeper than 1 on 2 down to a depth of 3 ft.; from that point outward the pit may be deepened with a slope of 1 on 10 when on the river side of the levee and 1 on 100 when on the land side.

The generally smaller levees below Red River and the more liberal pit specifications for them made the selection of a suitable type of machine for their construction much less problematical than the selection of a machine for levees above Red River. The machine selected was the drag-line excavator, of the self-contained, revolving locomotive crane type, arranged to operate an orange-peel, clamshell or drag-line bucket at a radius of 90 or 125 ft.

LOCOMOTIVE CRANE DRAG-LINE MACHINES

The machines are mounted on four-wheel trucks and are provided with the necessary mechanism for performing the operations of traveling and hoisting, rotating and operating a bucket. Track is provided for the machines to work on during low-water stages and barges from which to operate them during high-water stages. The barges are likewise used to transport the machines from one job to another. The crews of the machines are housed on quarter-boats. The first machine with its barge, quarter-boat, track and equipment cost approximately $40,000. The second and third machines purchased are stronger and of greater capacity than the first one, and the last machine purchased has been so successful as to warrant its adoption with minor modifications as a type for work in the Fourth District—particularly below Red River. This type machine will handle a 3-yd. orangepeel bucket or a 5-yd. drag-line or clamshell bucket at a radius of 126 ft. from the center of the machine. The cost of machines of this type fully equipped and provided with a quarter-boat for the housing and care of crew and coal barge for supplying it with coal will be approximately $60,000. This figure does not include the cost of a barge from which to operate it during high stages and with which to move the machine from point to point. The cost of a steel barge suitable for this purpose is about $18,000. It will not be necessary to provide a barge for every machine. It is thought that with these machines it will be possible to place earth in the levee system, wherever rehandling is unnecessary, at field costs of from 5 to 10c. per cu.yd.—exclusive of the cost of clearing and grubbing when this is necessary. When material can be placed in the levee without rehandling, this type of machine is believed to be the most efficient for levee work. (See Fig. 3.)

Above the mouth of the Red River the levees become much higher than below the Red, and this fact, together with the more difficult pit specifications, necessitates much wider borrow pits and therefore greater reach on the part of the machines. Inasmuch as pits, when once dug, do not fill up again, this is true whether the work is enlargement of existing levees or the construction of new lines. The considerably greater reach necessary led to the selection of cableway machines for trial in preference to drag-line machines. Cableways were first operated in the Fourth District. The first one to be operated outside of that district was near Memphis. This cableway was of the slack-line type, was designed by C. G. Oglesby and put in operation by R. H. and G. A. McWilliams.[2]

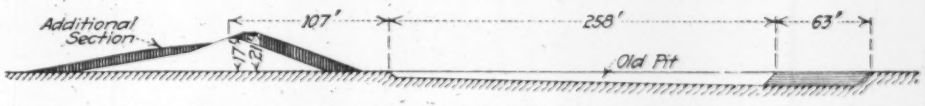

FIG. 1. AVERAGE CONDITION AND NECESSARY ENLARGEMENT OF LEVEES ABOVE GREENVILLE, MISS.

In the Third District the levees on the Mississippi side—except at the extreme lower end of the district—generally have banquettes, varying in width from 10 up to 20 ft. The banquettes have generally been added after the completion of what may be termed the main part of the levee. The main part of the levee has almost invariably been constructed from river-side pits, and the banquette generally, but by no means always, from land-side pits.

Above Greenville the average height of the levee system is 20.7 ft.; the average width of the existing river-side pits is 258 ft.; the average amount of material to be added to the existing levees to bring them up to the grade and section calculated to be necessary to contain safely such a flood as that of 1912 is 2,150 cu.yd. per station. In order to obtain this amount of material it is necessary to go out 63 ft. beyond the existing river-side pit. The outer edge of the resulting pit would then be 428 ft. from the center line of the crown of the existing levees. Even if this earth were all to be placed on the river side, drag-line excavators to do this work without rehandling would have to handle their buckets on booms approximately 200 ft. long. However, if the

[2]Described in "Engineering News," Sept. 10, 1914, p. 544.

enlargement is to be accomplished with the minimum of material, 610 yd. per station out of the total 2,150 yd. should be placed on the land side of the crown of the levee in order to widen and raise the banquette. This material can be placed cheaply by teams, if it is taken from land-side pits; but such pits are objectionable because they in a measure weaken the levee, take land capable of cultivation and mar the appearance of the land fronting on the levees.

When there is no banquette, the top of the levee can be readily cut down to the level of the new banquette and all the material then be placed on the river side, at the expense, however, of from 300 to 500 yd. per station extra; but when there is a banquette, it is seldom at the right height for the new banquette, and a satisfactory enlargement by this method can rarely be made.

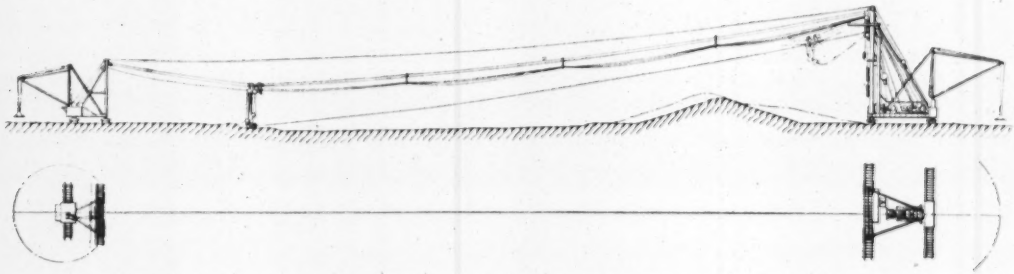

FIG. 2. LIDGERWOOD DRAG-LINE CABLEWAY EXCAVATOR USED IN VICKSBURG DISTRICT TO BUILD MISSISSIPPI LEVEES

A thin layer of earth must almost invariably be added to the banquette to bring it to the proper height, and thin layers of earth on the land side add little or nothing to the stability of a levee.

Taut-Line Cableway Type

A machine was therefore sought that would take all the material from the river side of the levee, beyond the limits of the old pits, and place it as needed either on the river side or land side. A taut-line cableway of the Lidgerwood type, equipped to handle a drag-line bucket, was thought to offer the greatest promise of meeting these conditions, and one was accordingly purchased by the United States and started to work at the extreme upper end of the Third District.

The first cost of a machine of this type, erected and equipped, is about $45,000. Its general features are shown in Fig. 2. It has a clear span of 662 ft. The towers are of steel, 85 and 45 ft. high respectively, and support between them a 2¼-in. cable. On this cable travels a carriage which carries a 3-yd. drag-line bucket. The carriage is moved back and forth by means of an endless line, operated by one of the drums of the main engine. The bucket is loaded by means of a cable which leads from the front end of the bucket to another drum on the main engine, and is lifted by means of a cable which is attached to the bail of the bucket and runs thence around a sheave on the carriage, over a sheave at the top of the head tower and thence to a third drum on the main engine.

A pull of 50,000 lb. for loading the bucket is developed by means of a special engine, which operates a haul-down rope which runs from the drum of this engine around one sheave of a double tandem block (the second sheave of which rides on the drag or loading line) and thence to the frame of the tower.

The bucket is dumped at will by means of a haul down rope which pulls down on the dumping [illegible] attached to the back of the bucket, and running thence to the conveying drum, thus accelerating the movement of the rear of the bucket relatively to that of the front end and consequently causing the back end of the bucket to lift and the material to dump. This haul-down rope is operated by means of a piston and steam cylinder. A special engine is provided on the head tower to move the same. The tail tower is moved by means of a friction drum operated by the conveying line.

Derricks were originally provided on both head and tail towers to pick up track from behind the machine. This method of handling proved satisfactory on the tail tower, three men being able to handle the track without difficulty. The long boom of the derrick on the head tower made this derrick unwieldy to handle by hand, and its use was therefore abandoned and the track thereafter dragged forward by means of the moving engine. An improved system of track handling is contemplated to be used on both towers during the coming season.

The frictions and brakes are all operated by compressed air.

The crew of this machine consists of one foreman rigger; one operator; one rigger's helper; one engineman; one fireman; one signalman; eight laborers (trackmen), three on tail tower and five on head tower; three laborers (dressing levee); three teamsters (ploughing, dressing levee and hauling supplies).

Table 2 gives the results of the season's (1915) work with this machine.

TABLE 2. WORK DURING 1915 BY LIDGERWOOD LEVEE BUILDER

Month	Yardage Placed During Month	Cost per Cu.Yd.	Yardage Placed Since Work Began	Average Cost per Cu.Yd
April	5,211	$0.1850	5,211	$0.1850
May	13,239	.1386	18,450	.1518
June	20,050	.1548	38,500	.1531
July	23,850	.1126	62,350	.1378
August	19,050	.1490	81,400	.1404
September	2,600	.7047	84,000	.1579
October	22,800	.1041	106,800	.1464
November	28,500	.1108	135,300	.1389
December	18,600	.2253	153,900	.1494

The very high costs of September were due to practically the entire month having been lost on account of high water, wet pits and delays incident to renewing the main cable—the latter due purely to bad management. The high cost of December was due to a flood and to the necessity of stopping work some days before actually drowned out, in order to prepare for a prolonged high water. Shortage of coal and the holiday season also cut down the output of this month. The past season was an exceptionally bad one for levee work, and progress was retarded throughout by wet pits.

Various parts of the machine which proved unequal to the strain it was desired to put upon them have been or are being replaced or strengthened by the Lidgerwood Co., and it is expected that delays during the coming season will be fewer and that the average cost per yard will be much less. It is thought that with proper management this machine should be able to build or enlarge levees at field costs ranging from 8 to 14c. per cu.yd. As the material falls into place from heights varying from 10 to 40 ft. it is believed that this type of machine builds a particularly good levee.

Slack-Line Cableway Type

The manufacture of slack-line cableways of the type developed by Mr. Oglesby has been taken up by the Bucyrus Manufacturing Co., which, after a careful study of Mr. Oglesby's first machine, built a greatly improved machine of this type for H. B. Blanks & Co. on their contract for levee enlargement below Greenville. It is understood that the cost of this machine, erected and equipped, is about $40,000. It has a clear span of approximately 450 ft. The head tower travels on the banquette, which has to be first enlarged by teams. The machine therefore builds only the river-side enlargement, which on this work averages about 1,800 yd. per station. The bucket is of 8-yd. capacity. The machine was not completed until about the middle of October, 1915. Between this time and the end of the year its output was as follows: October, 10,340 cu.yd.; November, 31,077 cu.yd.; December, 28,083 cu.yd.

On account of its working on higher ground and considerably lower down the river than the Lidgerwood machine, it was not compelled to stop work on account of high water until Jan. 8, 1916.

The crew of this machine comprises two foremen and riggers, two head-tower operators, one tail-tower operator, one oiler, one fireman, ten laborers (trackmen and dressers), one team and teamster.

The unit cost of work accomplished by the Bucyrus machine has been considerably less than that accomplished by the Lidgerwood machine, but it is not yet safe to draw final conclusions as to the relative merits or economy of these two types of machines. The conditions under which they have been working have been very different. The Bucyrus machine worked only during the best part of the last working season, whereas the Lidgerwood worked the entire season, was hampered most of the time by wet pits and was completely drowned out for the best part of one month. The Bucyrus has moved dirt an average distance of 310 ft., whereas the Lidgerwood has moved it an average distance of 412 ft. Building only the river-side enlargement, the Bucyrus machine has had only about 6,000 sq.ft. of levee to dress per station, whereas the Lidgerwood, which builds the banquette also, has had 17,200 sq.ft. per station to dress. The Bucyrus has had to haul its coal and supplies from ¼ to 1 mi., whereas the Lidgerwood has had to haul its coal and supplies from 4 to 6 mi. The Bucyrus has been working in a locality where labor is much more plentiful than in the locality where the Lidgerwood has been working. The Bucyrus has not been working long enough to necessitate much expense in the way of repairs or renewals.

It seems, however, safe to predict that the Bucyrus machine will build river-side enlargement or new levees at field costs ranging from 8 to 14c., exclusive of the cost of any grubbing and clearing that may be necessary. Its designers claim that it can be designed to enlarge existing banquettes or build banquettes behind existing levees and have constructed two machines so designed for Mr. Oglesby's use in the Second District. As these machines have not yet started to work, it is not safe to predict how successful they will be on banquette work.

Considerable difficulty has been experienced in getting the contractor operating the Bucyrus machine to leave pits conforming to specifications. This is thought to be principally due to the fault of the contractor, but is also in some measure due to the difficulty of controlling the bucket while being loaded and dragged through the pit to the levee. While the Bucyrus machine compacts the material to a certain degree as a result of dragging the heavily loaded Bucyrus bucket over the levee and because of the bucket's slipping back slightly just before dumping and thus ironing out, so to speak, the new material placed in the previous load, the Lidgerwood machine is considered to compact the material much more tightly as a result of the height from which the material falls.

FIG. 3. BUCYRUS DRAG-LINE MACHINE WORKING NEAR BATON ROUGE

The locomotive crane drag-line excavators have already reached a high stage of development, and improvements in their design will be slow from now on, but considerable further improvement is anticipated in cableways. The Bucyrus cableway is a long step in advance of the machine constructed by Mr. Oglesby. Experience with the Lidgerwood cableway has suggested many desirable improvements, and it is thought that the next Lidgerwood machine will be quite as much of an improvement on the one now in use as the Bucyrus purchased by Blanks & Co. is on the machine first built by Mr. Oglesby.

Most of the levee work on the Mississippi River will undoubtedly be done by levee-building machines from now on, at costs materially lower than it would be possible to do it by teams.

Land-Clearing and Stump-Pulling methods are to be demonstrated throughout the northern section of Wisconsin by means of an exhibition train operated by the University of Wisconsin over the lines of the Chicago & Northwestern Ry. and the Chicago, St. Paul, Minneapolis & Omaha R.R. The train will be equipped with different makes of hand- and power-operated stump pullers and with apparatus for blowing up stumps. Stops will be made at a number of towns, according to a schedule advertised in advance, and stump-removing operations will be exhibited. The work will be under the direction of Carl Livingstone, of the Agricultural Engineering Department, University of Wisconsin.

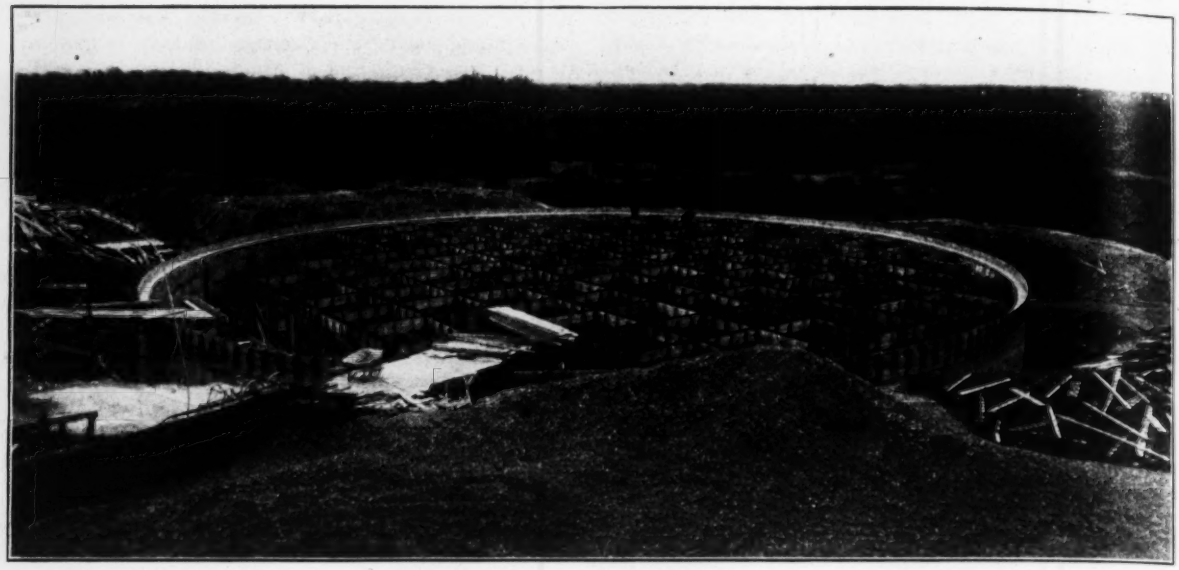

FIG. 1. COVERED REINFORCED-CONCRETE EQUALIZING AND STORAGE RESERVOIR FOR HIBBING WATER-WORKS

Covered Reinforced-Concrete Reservoir, Hibbing, Minn.

By R. E. McDonnell*

The water-supply for Hibbing, Minn., a village of about 12,000 population, is procured from a series of drilled wells. Most of the wells are so located that the water flows from the delivery pipe at the wells to a large equalizing and storage reservoir. A temperature of −50° F. is reached at Hibbing in winter, and as the wells are pumped intermittently, it is necessary to protect the water in the reservoir from freezing.

The reservoir is a reinforced-concrete tank with an inside diameter of 115 ft., is 14 ft. deep and holds about 1,000,000 gal. It is built on a glacial deposit of sand and gravelly soil, and to make it absolutely water-tight was necessary in this sandy formation.

The floor of the reservoir consists of two layers of 4-in. concrete slabs, between which is a layer of asphaltic waterproofing material. The roof consists of a 5½-in. reinforced-concrete slab, supported on 10x12½-in. reinforced-concrete columns, with footings enlarged to give an area sufficient to carry the reinforced-concrete roof slab, 18 in. of earth cover and snow which sometimes reaches a depth of 4 to 6 ft.

The roof of the reservoir will be sodded and arranged with flower beds in keeping with the other surroundings of the power house.

It is anticipated that a small amount of sand will be pumped from the wells. Accordingly, a sand trap has been provided to keep the sand from reaching the 24-in. suction line leading to the high-service pump. A glass-covered inspection chamber provided with electric lights affords opportunity to observe the water in both the sand trap and in the reservoir. The electric lights are embedded in concrete with special conduits for lighting under water.

The double floor slab is laid in blocks 8½ ft. square, with joints staggered and filled with asphaltic preparation. The concrete was waterproofed, and tests for leakage were made after the completion of the reservoir. It was impossible to detect any leakage after the reservoir had been filled for 48 hr.

In the construction of the reservoir the vertical walls were poured at one pouring from a circular track laid just above the vertical walls, and from this track the

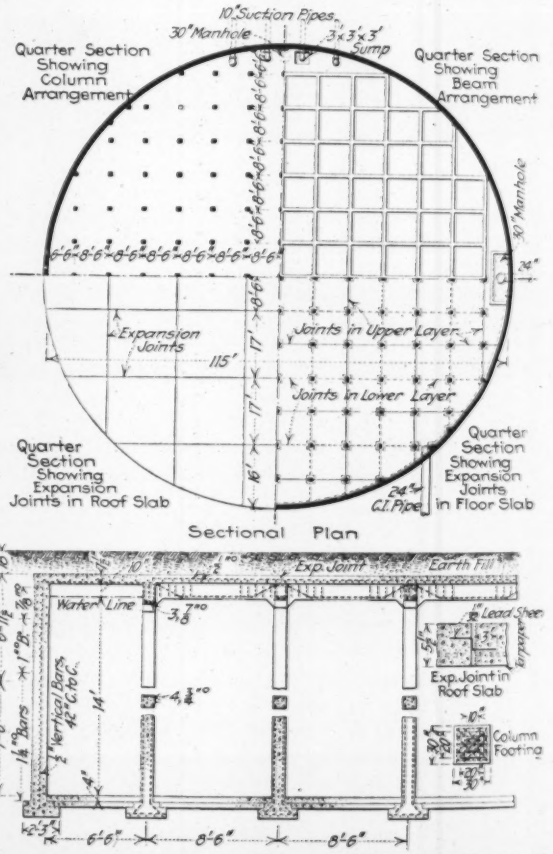

FIG. 2. PLAN AND DETAIL OF THE HIBBING RESERVOIR

*Of Burns & McDonnell, Consulting Engineers, Kansas City, Mo.

concrete was dumped from wheelbarrows into the vertical forms. The roof was likewise poured continuously.

The reservoir was a part of the general construction contract of Layne & Bowler Co., of Houston, Tex., but was built by subcontractor E. W. Coons Co., of Hibbing, Minn. It was designed and the construction was supervised by Burns & McDonnell, consulting engineers, Kansas City, Mo.

Legal Decisions of Interest to Engineers

Written Contract for Construction Work Supersedes Verbal Contract—Where the parties to a contract for railroad construction work did not execute the written contract until a few days before the work was completed, the written contract nevertheless governs and supplants any verbal declarations concerning the nature of the work, and that plaintiff would make a profit, which declarations were not inserted in the written contract.

The Arkansas Supreme Court came to the foregoing conclusion in the case of Robertson vs. Sharp Contracting Co. The Robertson Co. had the contract for constructing 50 mi. of railroad for the Malvern & Camden Railroad Co. The understanding was that certain of the work was to be classified as "wet excavation." Shortly before the completion of the railroad the parties reduced the terms of the contract to writing. The written contract, however, contained no "wet excavation" classification.

The question before the court was whether the construction company was bound by the written contract omitting the "wet excavation" classification or could recover for wet excavation work, as was the verbal understanding. The court held that the written contract must govern and supplant any verbal declarations concerning the work. (Robertson vs. Sharp Contracting Co., 183 S. W. 754.)

Buyer of Machinery May Refuse to Pay Note Where Machinery Does Not Fulfill Guarantee—Where a manufacturer of dredge machinery in making a sale accepts the purchaser's promissory note as part payment for the machinery, the purchaser may refuse payment of the note if it is later found that the machinery does not meet the warranty as to its fitness to perform the work for which it was sold. (Murray Co. vs. Palmer, 154 Pac. 1137.)

Contractor's Delay Through "World-Shared Ignorance" Is Not an "Unavoidable Cause"—By contract with the United States Government, the Carnegie Steel Co. engaged to furnish to the Ordnance Department armor plates, some of them to be 18 in. in thickness. Certain plates were to be delivered on specified dates for the ballistic test. The contract provided for liquidated damages for delay in delivery other than through "unavoidable causes, such as fires, storms, labor strikes, action of the United States," etc. The company failed to make timely delivery, and the United States retained part of the purchase price as liquidated damages. A demurrer to a petition in the Court of Claims for the recovery of this balance was sustained except as to a small part of the money retained.

It is claimed by the company that the delay was by "unavoidable cause." No hard-faced 18-in. armor plate had previously been manufactured in this or any other country, and no information was obtainable respecting the processes involved. The company made a single plate to determine the proper treatment and processes, but delayed the manufacture of the others, from which plates for government tests were selected, until it was demonstrated that the first plate answered all requirements of the contract.

Justice McKenna, in delivering the opinion for the United States Supreme Court, said: "It would seem that the very essence of the promise of a contract to deliver articles is ability to procure or make them. But claimant says its ignorance was not peculiar, that it was shared by the world, and no one knew that the process adequate to produce 14-in. armor plate would not produce 18-in. armor plate. Yet claimant shows that its own experiments demonstrated the inadequacy of the accepted formula. A successful process was therefore foreseeable and discoverable. And it would seem to have been an obvious prudence to have preceded manufacture, if not engagement, by experiment rather than risk failure and delay and their consequent penalties by extending an old formula to a new condition." (Carnegie Steel Co. vs. United States, 36 Sup. 342.)

Town Planning in Canada

By Thomas Adams*

What is known as "city planning" in the United States and "town planning" in Canada has not received the attention it should have received from the engineering profession. The problems that have to be solved in planning schemes are not only largely of an engineering character, but it is the engineer who has to prepare the foundation on which all schemes have to be built up. The under-emphasis which has been placed on the engineering aspects of the problem has been in part due to the indifference of engineers themselves. They will have to overcome this inertia in justice both to the movement and to themselves.

In the States men like Nelson P. Lewis, of New York, have taken a prominent part in city planning, but a wider interest is needed. In Great Britain practically the whole of 152 schemes in course of preparation are in the hands of municipal engineers. This does not mean that the architectural viewpoint is overlooked, but merely that the preliminary stages of planning require engineering and local knowledge which the architect does not possess as a general rule. The designing, placing and grouping of buildings, and even the layout of a park system have to follow the design of the street, drainage, and transportation systems, and owing to the necessarily individualistic method that has to be followed in the erection of buildings on separate lots, it is usually found that it is not practicable to apply any conscious design to large groups of buildings. On the other hand, the street system and transportation is customarily a matter for public control and comprehensive treatment.

Town planning in Canada is being placed in the hands of engineers and architects acting in collaboration. The Commission of Conservation is the advisory body for the whole Dominion and has its engineering and public-health experts. Housing and town planning are dealt with as twin problems, and the primary objects of all

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schemes are to secure (1) proper sanitary conditions, (2) convenience for traffic and (3) amenity or agreeableness in the development of land. Hitherto the owners of real estate have been allowed to plan their land with the sole object of private gain and greatly to the inconvenience of the public. More coöperation is needed in the interests of such owners themselves, and eminently in the interests of the public welfare.

The passing of legislation to give city, town and municipal councils powers to prepare proper schemes is the first essential. Four provinces out of nine in Canada have now town-planning acts, and the other five provinces are likely to have acts on their statute books within another year. Nova Scotia has a compulsory act which requires that the whole province must be the subject of a scheme of planning within the next three years. These schemes have to provide for:

1. Main thoroughfares (up to 100 ft. wide).
2. Building lines (40 to 60 ft. from the center of each street of whatever width).
3. Narrow residential roads of short length (24 to 66 ft. according to traffic requirements.)
4. Reservation of residential and manufacturing areas.
5. Restriction on extent of lot to be built on and number of dwellings to each acre.
6. Preservation of features of natural beauty and restriction on nuisances, billboards, etc.
7. Provision of air space surrounding and within dwellings, etc.

The street system of each municipality has to work in with the general highway plan of the whole province. Wide main thoroughfares have to be arranged by "give and take" arrangements with real-estate owners by which complementary narrow streets are permitted in places where traffic requirements are light. Thus these main thoroughfares have not to be made at the cost of the general taxpayer, but by a sensible variation in width under a scheme. Fixing widths of streets by ordinance or by law is always unsatisfactory because such ordinances have to be specific in character and general in their application. Town-planning schemes allow discretion to be used and every street or other feature to be considered on its merits.

Of the schemes under consideration in Canada the largest, and the first statutory scheme to be started, is that of St. John, N. B., which deals with about 20,000 acres, of which half are inside and half are outside the city. Although the application to prepare this scheme carried with it the power of the City Council to restrict real-estate development, and to prevent any owner from contravening the proposed scheme, before it was prepared, only one owner raised an objection and was overruled.

A plan has been prepared by a special commission for the reconstruction and replanning of the capital city of Ottawa. The expert advisers were Mr. Bennett, architect, of Chicago, and Mr. Cousins, civil engineer, of Toronto.

Another development in Canada for which the Commission of Conservation is responsible is the formation of a Civic Improvement League for the Dominion. The object of this League is to educate public opinion so as to use the new town planning powers. A strong engineering committee of the League has been formed under the chairmanship of the Ontario Deputy Minister of Highways to prepare a report on Highways and Transportation. The good-roads movement has also linked itself up with the town-planning movement, so that the planning of highways is being considered side by side with methods of construction.

Extensometer Tests on Three Types of Concrete Floors

The City of Seattle, under its building code which went into effect in August, 1913, can require full-size tests of completed reinforced-concrete floors. Under this provision of the building law the city has within the past year tested three types of reinforced-concrete floors, namely, the Turner "Mushroom" floor, the Condron "Akme" floor, and an ordinary girder, beam and slab floor. The tests, which were made with extensometer readings of steel and concrete deformations, form the main part of the January-February, 1916, issue of the "Proceedings" of the Pacific Northwest Society of Engineers.

The papers are entitled "Tests of the Bell St. Warehouse of the Seattle Port Commission" by Almon H. Fuller and Charles C. Moore, of the University of Washington, and "Tests of the Sears-Roebuck Building and of the New Courthouse of King County" by D. E. Hooker, Assistant Superintendent, Seattle Building Department. In both the papers the data are given very fully, so that any one who is interested in the subject should obtain a copy of the Proceedings from the secretary of the society at Seattle. A brief description of the main facts brought out in the papers will be given below.

Tests of Turner Flat-Slab Floor

The Turner flat-slab floor tested was on the third floor of the Bell St. warehouse built by the Seattle Port Commission. This floor, designed according to the well known disposition of steel used by C. A. P. Turner, consisted of two wall panels 20 ft. 9 in. by 19 ft. 4 in. and two adjacent interior panels 20 ft. 9 in. by 20 ft. The design called for a 10¾-in. slab with four-way bands 9 ft. 6 in. wide, each carrying seventeen ½-in. rounds placed 10 in. from the top of slab in the middle of the span and 8 in. from the bottom at the column capital edge. The outer ring of the spider is a ¾-in. round, 9 ft. 6 in. in diameter and the inner ring a ⅞-in. round 6 ft. 9 in. in diameter at the interior columns and 5 ft. 6 in. at the wall column. The column capital is about 6 ft. in diameter at the floor. The floor was designed for a live-load of 500 lb. per sq.ft. and a dead-load of 144 lb. per sq.ft. Loadings of sheet tin in boxes were placed in increments of about 265 lb. per sq.ft. on all four panels until a final total test load of 700 lb. per sq.ft. was placed all over the four. In taking off the load a part was left on the wall panels while the other two were unloaded but at no time were the wall panels fully loaded while the interior panels were empty.

At the time of the test the floor was 113 days old (December-April) and there appears to be a controversy as to the condition of the concrete. The building department claimed that while the weather was cold when the slab was poured and remained damp and chilly for a considerable part of the time thereafter, still the conditions were not so adverse but what the concrete should have at least attained the strength it would under best conditions in 28 days, which is the time called for a test under the provisions of the building law. Mr. Turner's representative, however, claimed that the concrete was subjected to such low temperatures that it could not be expected to attain a proper strength in the period before the test. On account of this controversy and also on

account of some others which will be noted hereafter, the building department has announced that it will make another deflection test on some other portion of the building if possible.

Gage points were put in the steel and concrete in the upper and lower parts of the slab before the floors were poured and readings were made upon these points. At the same time, deformation tests were taken on concrete cylinders poured at the time the concrete of the floors was poured and also on concrete cut from the floors. The moduli of elasticity obtained from these small pieces were used in determining the stress in the concrete of the building. Tests on steel were also used to determine the moduli for the steel in the building. It should be said that the determination of the moduli for the concrete is none too conclusive.

The facts regarding the stresses determined are briefly stated in the paper as follows:

> In the mushroom head of the interior columns the direct stresses in the ring and radial rods are within reasonable limits. In the wall columns the stresses are high in the concrete on the inside, but reasonable in amount in the vertical steel. A tension, however, approximating ordinary working stresses occurs in the outside rods. The stresses in both steel and concrete are within reasonable limits in the interior panels, but abnormally high in the wall panels, particularly the concrete stresses immediately adjacent to wall columns. The deflection of the wall panels exceeds that in the interior panels by more than 50% under a uniform load. A load only on wall panels induces greater stresses than a load of the same intensity on the adjoining panels as well.

In figures, the deformations show that the steel stress near the wall columns in some rods is as high as 50,700 lb. per sq.in. where the yield point of the steel is about 50,000 lb. and that concrete stress near the column is at least as high as the breaking stresses in the concrete tested; that is, 2,000 lb. per sq.in. All of this is under an external load of 700 lb. per sq.ft. when the designed load was 500 lb. per sq.ft. In addition, a number of hair cracks became visible under the second increment of load. The deflection under maximum load was 0.81 in. in the wall panel, recovering to 0.38 in. in three days and 0.41 in. in the interior panel, recovering to 0.14 in. in three days.

In discussion of the paper the designer, A. O. Powell, stated that while he was responsible for the selection of the system and for the original design, the work was entirely under the direction of the port of Seattle's engineers and that he had no control whatever over construction. The high stresses found were due mostly, in his opinion, to the testing of the slab before it had reached its final set. He also called attention to the fact that the steel in many cases was far out of place. In places where it was designed to be 8 in. above the bottom of the slab, it was found to be 5 in. On this account he claimed that the designed load should not be used in a comparison with the test loads.

Tests of Akme Flat-Slab Floor

The Sears-Roebuck Building is nine stories high, all the floors being built on the well-known "Akme" two-way system sold by the Condron Co. of Chicago. Tests were made over four panels, two interior and two wall panels, 52 days old (April-June). The panels were 20x20 ft. on the interior and 20x18 ft. at the wall, and the slab is 8 in. deep at the middle and 14 in. deep at the depressed head. The floor was designed for 200 lb. per sq.ft. live-load, and a dead-load of 125 lb. per sq.ft., although at the time of test the dead-load was only about 100 lb. per sq.ft. as the cinder fill was not in place. Test loads consisted of increments of about 200 lb. bringing the maximum up to 550 lb. per sq.ft., which it will be noted is about twice the design plus the dead load. These tests were made by the extensometer method, although the test points had not been placed during the construction of the building. Moduli of elasticity determined in the Bell St. warehouse test were used for the concrete and the steel. Under this arrangement the floor showed up very well in practically all points, the greatest steel stress being 27,300 lb. per sq.in. at the top of the slab; the greatest stress in concrete, about 1,000 lb. per sq.in. Maximum deflection was 0.18 in., with recovery approximating 100%.

The one important fact stated by Mr. Hooker in regard to the Sears-Roebuck Building was the effect of the eccentricity of load on the wall columns. According to Mr. Hooker, this effect is of such marked extent that it should always be taken into consideration in flat-slab design. Either flat-slabs at walls should be carried by spandrel beams, the wall panels being considered freely supported at the walls, or the columns should be sufficiently reinforced to care for the eccentric moment otherwise developed. It may be noted that the tested floor was next to the top floor of the building and the column was therefore carrying in addition to the test load only one floor slab and a roof slab, so that it did not have the restraining effect of an upper load which would be characteristic of a lower column. Also the brick walls and the spandrel beams were not in.

Tests of Plain Beam and Slab Floor

The new Court House of King County was an ordinary beam and girder reinforced-concrete building. The test area was one panel wide and three panels long, extending across one wing of the building on the fourth floor, and when tested was 128 days old (February-June). Remarkably small deflections and stresses were found. The maximum deflection noted under the final test load was little more than ¼-in. in the center of a 31-ft. span. The greatest observed stress in the center of the long span was somewhere in the neighborhood of 6,000 lb. per sq.in. in the steel, and 450 lb. in the concrete. These were stresses occasioned by maximum live-load which amounted to 1.2 times the designed live and dead loads. The design load was 65 lb. per sq.ft.

Mr. Hooker says concerning this test:

> One fact stands out distinctly; that is, that slab action or shear or arching, or whatever one might call it, distributes stress far beyond the loaded width of floor out into the adjacent panels, and that concrete tension and arch action in the direction of spans reduce stresses very materially. If this were not true, the observed stresses would seem to refute the accuracy of assumptions which are used constantly in design. I believe these and similar field tests emphasize a fundamental difference between so-called flat-slab designs and ordinary designs consisting of slabs, beams and girders. The latter are based on mathematically demonstrable theories of beam action. When executed in a building we often find upon test actually much lower stresses than our theories indicate. Why? Because we gain an additional factor of safety from arching, concrete tension, and the tendency of adjacent panels to assist the loaded panels. On the other hand, flat-slab designs are worked upon empirical formulas, not mathematically demonstrable but worked out from observation of the action of test panels in completed buildings, and advantage has already been taken of arching, concrete tension, etc. Hence while we find lower stresses than we expected in the girder and slab floor, we often find as high or higher stresses than we expected in the four-way flat-slab floor.

Field and Office

Replacing Timber Bridge with Steel-Girder Spans

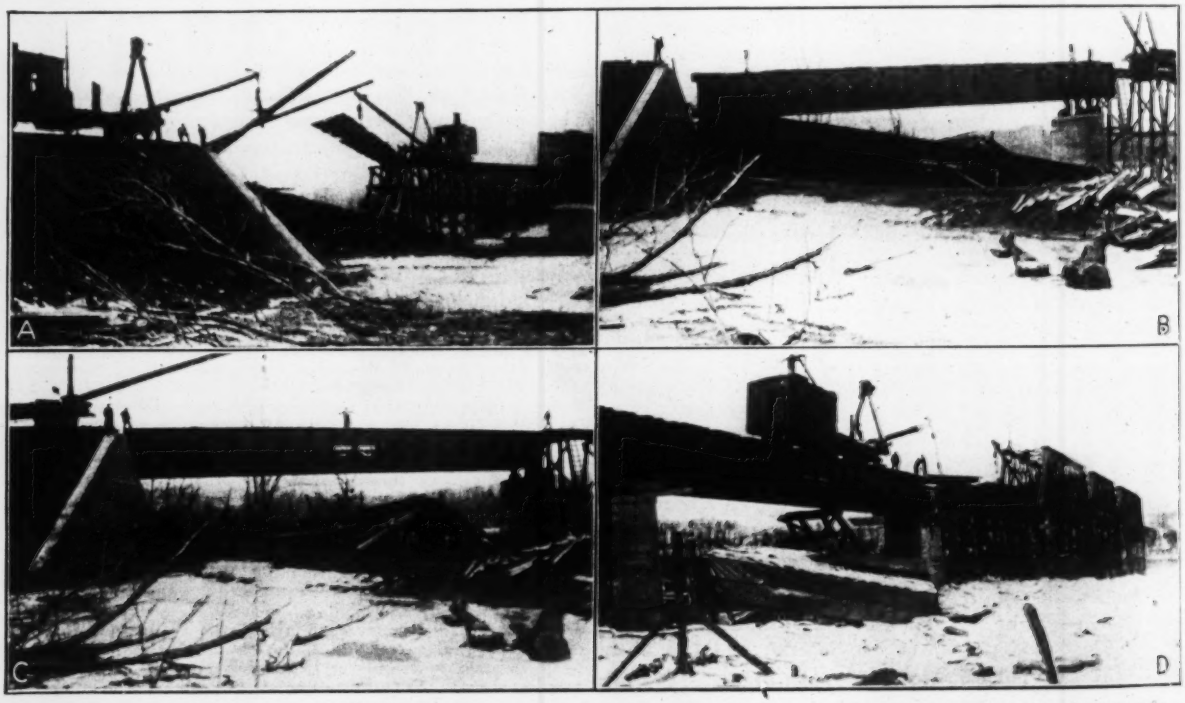
The Fort Dodge, Des Moines & Southern R.R. (a 120-mi. electric railway) crosses the Des Moines River at a point about 6 mi. west of Boone, Iowa. The original structure, built in 1903, before the road was electrified, was a wooden bridge consisting of one 150-ft. and two 104-ft. Howe truss spans, with 692 ft. of trestle approaches. The new bridge will consist of four 96-ft. and three 103-ft. steel deck-girder spans, the remaining 357 ft. being filled. Three of the 96-ft. spans were placed in the fall and winter of 1914-15, and three of the timber spans are still in place. The progress of the work is shown in the accompanying views.

The concrete work on the abutments and piers was done by company forces. The equipment consisted of a ⅝-yd. mixer and a timber tower with a steel boom to support the chute. The boilers supplying the mixer and hoist engines were interconnected. Water for boilers and mixer was drawn from the river by means of a steam jet fitted with a Y connection, which could deliver water either to boilers or to mixer.

The gravel was hauled to the site in ballast cars and dumped over the side of the bridge at a point convenient to the work. The cement was chuted from the cars on the bridge above to a platform at the cement shed.

The original plans called for 700 cu.yd. of concrete in the abutment and 200 cu.yd. in each of the three piers, but the footing of the abutment was placed about 4 ft. lower than at first intended, thereby increasing the yardage to 1,450. The force consisted of two enginemen, two firemen, one man operating the hopper, one man wheeling cement to the mixer, three men wheeling gravel, and one man spading concrete as it was dumped into the forms. Four men were used on the forms, and from eight to ten men were excavating for the piers while the concrete of the abutment was being placed. With this force and equipment 80 cu.yd. per day was placed when no delays were incurred. The average for the total number of working days was 60 cu.yd. per day.

The filling of 280 ft. of the pile approach on the south end was started Nov. 25. The average height of this fill was 25 ft. The material was hauled from the company's gravel pit, about 2 mi. from the bridge. The equipment consisted of a Vulcan 2-yd. steam shovel, 40-ft. side-dump gondola ballast cars pulled by a 35-ton electric locomotive, and a standard gravel plow with a 1¼-in. cable. The plow cable was coupled to the engine by a Goodman wrecking hook, which after trials of other devices was found the most satisfactory for this purpose. This work was finished Dec. 8; 8,000 cu.yd. was placed by this method in the ten elapsed working days.



REPLACING A TIMBER-TRUSS BRIDGE WITH PLATE-GIRDER SPANS, FORT DODGE, DES MOINES & SOUTHERN R.R.

A—Girders for new end span landed on the ground and two derrick cars removing deck of old trestle. B—Placing the first girder with two derrick cars; note sway bracing on girder. C—First girder span completed. D—Two derrick cars setting girders of third span in place, girders temporarily outside of normal position, resting on cap timbers on piers. Three of the old timber spans still standing.

The work of steel erection was done by contract in February, 1915. To handle the girders the contractor used two derrick cars, one of 75-ton and one of 50-ton capacity. The plan first proposed was to build falsework bents upon which to land the girders; but after only two bents had been driven, the ice went out, carrying the bents with it. This plan was then abandoned, and the girders for two spans were first landed on three 8x16-in. stringers, 32 ft. long, placed flatwise across the piers. For the end span, the girders were placed on the ground.

The old wooden deck was then cut directly over the piers and halfway between them. A derrick at each end of the span picked up half of the deck and carried it out to the fill at the end of the bridge. Then with a derrick at each end the girders were landed in place. These changes were made, the new track laid and traffic resumed in three hours. One span was erected each day, all the steel being placed in three consecutive days.

The work was done under the direction of the Maintenance-of-Way and Bridge and Building Department: L. E. Gagnon, Superintendent of Maintenance-of-Way; R. L. Cooper, Chief Engineer. The late W. M. Hughes, of Chicago, was consulting bridge engineer. The Farrell Construction Co., of Chicago, had the contract for the steel erection.

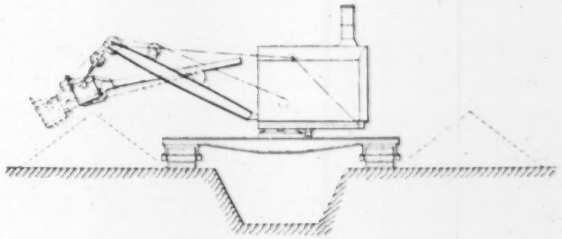
Power Shovels for Trenching

Practically any power shovel can be rigged to dig a trench. The best one for such service is the one that requires the shortest time for set-up, can handle the most material in a given time and costs least for repairs. Ordinarily a steam-shovel boom is maintained at a definite angle by means of hogrods. In the past six months at least two manufacturers have concluded that an arrangement for raising and lowering the boom has advantages over the rigid boom rods. This involves the use of an extra drum installed on the stayframe and geared to the main hoisting drum. A ⅝- to ⅞-yd. shovel—the popular size for small contractors—is generally equipped with a 17-ft. boom and dipper sticks 18 to 19 ft. in length. In order to go down 14 ft. or deeper, this boom and dipper handle have to be replaced by a boom 20 ft. long and a dipper handle 22 ft. in length.

With a boom raising and lowering device the extra reach required for deep digging is obtained by dropping the boom a few feet. The Osgood Co., of Marion, Ohio, which employs this arrangement except where the contractor specifies hogrods, cites a recent case where one of its Model 18 shovels, equipped with this device, excavated a sewer trench 46 in. wide, 15 ft. deep and 150 ft. long in a 9-hr. day. The material consisted of very dry and hard clay mixed with boulders. In another instance a similar machine excavated a sewer trench 17 ft. deep, 9 ft. wide and 76 ft. long in 7½ hr., loading one half of the material in wagons and depositing the other half on one side of the trench.

Like other shovels, this model may be equipped with a ¾-yd., a ⅝-yd. or a ½-yd. dipper, depending upon the nature of the material encountered and the kind of work to be done. For sewer-trench work the manufacturer recommends a special narrow dipper with the hitch on the back. In extremely deep work this type of dipper greatly reduces interference in filling. The dipper is generally fitted with five teeth, three in front and one on each side, the side teeth serving to draft the dipper into the side banks of the trench. A cutting lip is available (instead of teeth) wherever the character of the soil suggests its use.

The raising and lowering arrangement is, of course, not an exclusive feature of any shovel. All makers have



SMALL REVOLVING STEAM SHOVEL MOUNTED ON WIDE TRUCK FRAME EQUIPPED WITH CATERPILLARS

This arrangement—Osgood 18 fitted with boom raising or lowering device—is applicable naturally to soft ground, and avoids planking or artificial foundations. It is effective in excavating lateral ditches and in deepening or widening old channels.

used it in special instances, such as where the shovel is equipped with an exceptionally long boom for grab-bucket work, for locomotive-crane or derrick service, or for work in cities where the shovel must pass under overhead obstructions. If the contractor is willing to pay the extra cost occasioned by this device (about $150 in the case of small shovels), any shovel manufacturer can accommodate him. That the expense is worth incurring where there are trenches to be dug with steam shovels cannot be denied.

Red-Lead Finishing Coats

Since the Havre de Grace bridge test showed three-coat red-lead work in first and second place for endurance there has been some attention given by bridge engineers to the use of red lead for finishing coats. The most interesting recent case of red-lead top coats is the heavy plate-girder crossing of the Nickel Plate over the Illinois Central R.R. at 79th St., Chicago, whose design and construction were described in *Engineering News* recently. The structure was painted with three coats of red lead, the second and third coats being tinted with lampblack to different shades. The third, or final, coat was mixed with 6 lb. of lampblack per 100 lb. of red lead, giving a very dark brown color. The total rate of paint consumption on this structure was 1 gal. per 20 tons of steel, but in considering this it must be mentioned that the floor steel is incased in concrete and thus does not expose any painting surface; if the figures are corrected by taking account of the tonnage not painted, the steel covered is about 11 tons per gallon, according to George H. Tinker, Bridge Engineer.

The lower 5 ft. of the Sewall's Point coal pier, Virginian Ry., was painted three coats of red lead—the top coat black and the second coat brown, obtained by different admixtures of lampblack. F. F. Harrington, Engineer of Structures of the railway, says that the following paint mixtures were used, after cleaning the steelwork and removing the rust with scrapers and iron brushes:

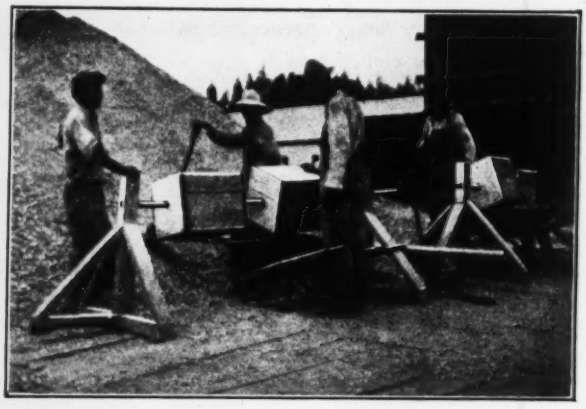
	First Coat	Second Coat	Third Coat
Paste red lead, lb.	100	100	100
Lampblack-in-oil, lb.	...	6	52
Chinese blue-in-oil, lb.	...	...	16
Linseed oil, gal.	2.9	3.64	15.20
Paint, gal.	5.02	6.42	24.55

For general use the National Lead Co., which is largely interested in paste red lead, recommends lampblack additions ranging from a few ounces to about 6 lb. per 100 lb. red lead. For a light brown, 12 oz. of paste lampblack is added; 4 to 5 lb. will give a dark brown, and 6 lb. a very dark color. These browns lack all the glaring orange quality of the natural red-lead color. Handsome green colors are obtained by the use of chrome yellow and Prussian blue; 31 lb. of chrome yellow and 13 lb. of Prussian blue per 100 lb. of red lead give a rich dark green. As this addition is accompanied by a considerable increase of oil, the expensive colors do not add to the cost of the paint as much as might appear. At normal peace-time prices the last-mentioned paint costs about 25c. per gal. more than red-lead paint, according to F. M. Hartley, of the National Lead Co.

Measuring Concrete Aggregate in Revolving Boxes

By H. B. Andrews*

The revolving measuring boxes shown in the accompanying view have been successfully used by the Coronet Phosphate Co., of Hillsborough County, Fla., in the construction of a reinforced-concrete dry bin. The yardage did not warrant the construction of sand and stone bins, and the mixing yard consisted of the usual



CONCRETE AGGREGATE MEASURED IN REVOLVING BOXES

loading platform adjacent to the cement shed. Both the sand and the stone had to be wheeled up runways to this platform, and the revolving boxes were used in measuring both the sand and the stone. The cement was measured and discharged direct into the mixer.

The boxes are proportioned in size to hold the exact quantity of each material and are placed on 1¼-in. pipe as axles, with two or more boxes to the stand as desired. The pipe is carried through holes in the 4x4-in. posts, which are braced and carried on a 4x4-in. support.

A dry batch of 10½ cu.ft. of 1:2:4 mixture was used and required three 2-cu.ft. stone boxes, two 1½-cu.ft. sand boxes and one 1½-cu.ft. cement box. The framework was light and could easily be moved into the stone or sand piles or from one job to another. The whole framework is detachable and can be taken down in a very few minutes.

The bottoms of the boxes were high enough to allow a wheelbarrow beneath in such a way that the box could be turned on the pipe, discharging the load and righting itself for loading. The apparent objection to this form of loading is in the height of shoveling the material, but by using scoops the boxes were quickly loaded and the additional height was not objectionable. Delays in loading were eliminated, and a uniform mixture was obtained.

Bedding Cement Pipe Sewers in Lean Concrete

Experience in Austin, Tex., with concrete sewer pipe made by city day labor at the city plant has been quite satisfactory. The concrete is mixed 1:3, using a natural gravel aggregate from the Colorado River bed. It is mixed very dry and thoroughly rammed into steel forms, so that the forms may be removed a short time after the pipe is cast. When removed from the forms the concrete has about the stiffness of green clay sewer pipe. The pipe is kept moist and cured in the shade. The concrete is mixed with a small batch mixer.

The only weakness developed in this pipe and the only fractures found in storm sewers constructed of it have been traced to improper bedding of the invert. The soil under the city streets is a hard lumpy gravel, and it is not possible to secure a good bedding by tamping it around the pipe. This problem has been solved by the use of 1:18 concrete for bedding the lower half of the pipe.

The 2-ft. sections of pipe have plain ends, without bells or spigots, and the joints are made by butting the ends together and plastering them inside and outside with 1:1 mortar. Ordinary curves and bends are made by cutting away the pipe and fitting the ends as close together as possible and then filling the joints with mortar. The omission of bells not only represents a saving in cost of construction, but prevents loss from breakage in handling.

Spacing of Shear Steel in Concrete Beams

By Robert S. Beard*

The location of stirrups in a reinforced-concrete beam is generally graphically determined as shown in the accompanying diagram, which is a method of subdividing the shear triangle into n equal areas to be provided for by n bent-up rods or stirrups. First, a semicircle is drawn on AB, the length leg of the shear triangle. Next, this leg AB is divided into n equal parts, and perpendiculars are erected at the division points. The compass is then centered in the vertex A, and concentric arcs of circles are drawn passing through the intersection of each perpendicular with the circumference of the semicircle. Perpendiculars to the leg AB drawn from its intersections with these arcs divide the triangle into n equal areas. The rods are then spaced in the beam so as to pass through the intersections of the neutral axis with the perpendiculars to AB drawn through the centers of gravity of the n respective areas.

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TABLE SHOWING SHEAR STEEL SPACING IN REINFORCED-CONCRETE BEAMS

The figures give distances from supports in decimal parts of the length of the shear triangle

Bar Number Counting from Center of Beam	Number of Shear Bars in Half of Beam																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.3333	0.5286	0.6151	0.6667	0.7018	0.7278	0.7480	0.7643	0.7778	0.7892	0.7991	0.8075	0.8151	0.8218	0.8279	0.8333	0.8383	0.8429	0.8471	0.8509
2		0.1381	0.2962	0.3905	0.4548	0.5023	0.5392	0.5690	0.5937	0.6146	0.6327	0.6480	0.6619	0.6742	0.6853	0.6952	0.7044	0.7128	0.7204	0.7274
3			0.0886	0.2107	0.2939	0.3555	0.4033	0.4419	0.4739	0.5009	0.5243	0.5442	0.5622	0.5781	0.5925	0.6053	0.6171	0.6280	0.6380	0.6470
4				0.0654	0.1639	0.2368	0.2934	0.3391	0.3770	0.4090	0.4367	0.4603	0.4816	0.5004	0.5175	0.5326	0.5466	0.5595	0.5713	0.5820
5					0.0516	0.1343	0.1986	0.2504	0.2933	0.3296	0.3611	0.3878	0.4120	0.4333	0.4527	0.4698	0.4858	0.5004	0.5137	0.5258
6						0.0428	0.1138	0.1711	0.2186	0.2587	0.2935	0.3231	0.3498	0.3734	0.3948	0.4138	0.4314	0.4475	0.4623	0.4757
7							0.0365	0.0988	0.1504	0.1940	0.2319	0.2640	0.2931	0.3187	0.3420	0.3626	0.3818	0.3993	0.4154	0.4299
8								0.0320	0.0874	0.1342	0.1749	0.2094	0.2409	0.2681	0.2932	0.3153	0.3359	0.3548	0.3720	0.3876
9									0.0284	0.0783	0.1215	0.1583	0.1915	0.2208	0.2475	0.2711	0.2930	0.3131	0.3314	0.3480
10										0.0255	0.0713	0.1101	0.1452	0.1762	0.2044	0.2294	0.2525	0.2738	0.2932	0.3107
11											0.0236	0.0645	0.1014	0.1340	0.1636	0.1898	0.2142	0.2365	0.2569	0.2754
12												0.0208	0.0594	0.0935	0.1245	0.1520	0.1774	0.2009	0.2222	0.2415
13													0.0197	0.0552	0.0876	0.1162	0.1427	0.1671	0.1894	0.2095
14														0.0179	0.0515	0.0813	0.1089	0.1342	0.1574	0.1783
15															0.0170	0.0478	0.0764	0.1027	0.1266	0.1483
16																0.0156	0.0452	0.0723	0.0972	0.1196
17																	0.0151	0.0431	0.0687	0.0918
18																		0.0142	0.0406	0.0644
19																			0.0135	0.0380
20																				0.0124

The subdivision of the shear triangle can also be done analytically and the following formula arrived at:

$$z = a\left[1 - \frac{2}{3\sqrt{n}}(s^{\frac{3}{2}} - \overline{s-1}^{\frac{3}{2}})\right]$$

in which

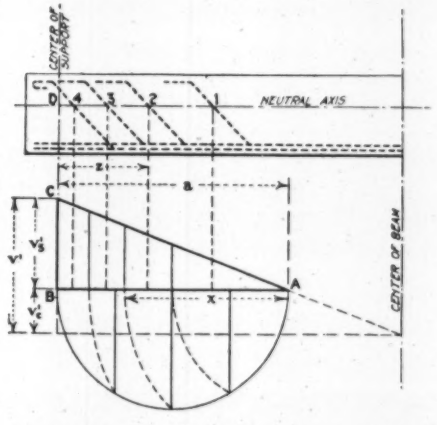
z = Distance of center of gravity of any subdivision from B;

a = Length leg of shear triangle;

n = Number of subdivisions;

s = Subdivision or rod number counting from A.

The length a is the only value in this expression which for any given total number of rods is dependent upon the particular shear triangle in question. The accompanying



table, which has been calculated by Clifton M. Kerr, of the Kansas City Engineering Department, and the writer, is a series of solutions of the quantity within the brackets.

If the base of the shear triangle is drawn parallel to the neutral axis of the beam, the total number of stirrups n needed in one-half of the beam can be found by dividing the product of the area of the steel shear triangle and the breadth of the beam by the working strength of one stirrup; that is,

$$n = \frac{v_s' ab}{P} \qquad (a)$$

but for bent-up rods, as explained hereafter,

$$n = \frac{v_s' ab}{1.42P} \qquad (b)$$

where

v_s' = Part of the shear carried by the steel;

b = Width of beam;

P = Working strength of one stirrup.

The distance along the neutral axis of each stirrup or rod from the support is then found by setting the value of a on the slide rule and multiplying it successively by the coefficients in the proper n column in the accompanying table corresponding to the different rod numbers.

The analytical method of determining the proper spacing of the web reinforcement is made more rapid than the graphical method by the use of this table.

The strength P required of a stirrup or rod is $P = vbs$ for the stirrup and $P = vbs \cos 45° = 0.707\ vbs$ for the bent-up rod. From this it is evident that the value of s for a bent-up rod may be 1.42 times that of a stirrup of the same cross-sectional area. Therefore, a smaller number of bent-up rods than stirrups of the same strength are needed to provide for any given shear area. Of course, the longitudinal spacing of the stirrups or bent-up bars should not exceed three-fourths of the depth of the beam in any case.

The companion table to this, showing where rods are no longer needed for moment, was published by M. J. Lorente in *Engineering News*, Mar. 20, 1913, p. 571.

Location Survey Methods for Irrigation Canals

The following is a detailed description of the procedure in locating the Main Canal, Division 4, from Sta. 1933 west, Grand Valley Project, United States Reclamation Service. This work was done in 1915 by Lyman E. Bishop, locating engineer, now Deputy State Engineer of Colorado, and C. H. Howell, surveyman, Reclamation Service. These surveys and those for location of the laterals of the Second District, subsequently described, were made under the supervision of S. O. Harper, Assistant Engineer, in charge of all fieldwork on the project. The Project Manager is J. H. Miner.

For the main canal, which was to carry from 330 to 120 sec.-ft., the "fly line" method of location was used throughout. A diagram for each canal cross-section was prepared, which showed excavation and embankment quantities (these latter increased 10% for shrinkage) for all center-line cuttings to be encountered. The diagram was so arranged as to show the "economic" center cut required to produce a balance between excavation and embankment for ground slopes from 0 to 50%.

The "fly line," first established, is essentially a grade contour, marked at each station by a lath stake. These stakes were set by level at the proper economic cut for the existing ground slope. The location to fit the topographic conditions was then worked out in the field. All

curves were given a radius greater than six times the bottom width of the canal. Ridge cuts and fill locations were adopted only after various alternatives had been run out on the ground and the comparative yardage estimates had demonstrated the economy of these ridge cuts or fills. As soon as the location line was established, levels for a profile were taken on the center line. Transit and level notes were kept in the usual manner, but in addition to the ordinary level notes a record was kept of the ground slopes, to be used in the estimates.

The office work included the preparation of a profile and alignment map, yardage estimates and a haul diagram prepared from the yardage estimates. Topography taken by transit and stadia at the more important crossings was plotted to accompany the alignment map.

The location party consisted of ten men as follows: A locating engineer, a transitman, a levelman, two chainmen, a rodman, a draftsman, a back-flagman and two teamsters (with their teams). In less than two months this party completed the location of 22.1 mi. of canal, involving the running of about 25 mi. of transit lines and 46 mi. of levels. An average progress of 0.42 mi. per day was attained. Some few changes were subsequently made in this line by C. H. Howell, who was in immediate charge of the surveys for location of laterals.

Methods Used in Lateral Location

Subdivision surveys, based on the section and quarter-section corners of the public-land surveys, were generally the first to be made. The approximate location of the laterals was roughly projected on a contour map and this was taken into the field and studied during the subdivision survey. The acreage was obtained from this map for each system of laterals and a ditch cross-section chosen (from a previously prepared table) which would be large enough to meet the requirements. All laterals were designed to deliver 1 sec.-ft. to 40 acres.

Three general methods of location were used, depending on the topography of the area in question and the proximity to the main canal—(1) the contour method, (2) the land-line method, and (3) the ridge-line method.

1. The contour method was used on all sidehill work and in paralleling the main canal on a grade contour. From the grade at the point of departure at the main canal a line of lath stakes was set by level, rod and chain, according to the economic cut and on the rate of grade adopted. The economic cuts for the different side slopes were obtained from a table, previously prepared, as noted before.

This line of stakes was then lined in so as to reduce the P. I.'s to a minimum, and the external distances were measured to determine the best alignment. A transit line was then run from P. I. to P. I., and if the lateral was large enough to warrant, curves were fitted; otherwise the angles were simply read and ties made at land-line crossings. Levels were then run over the located center line for a profile and the slopes taken at intervals for the preliminary estimates.

2. The land-line method was adopted wherever it was considered at all feasible. This consisted of locating the center line of the laterals on the boundary lines of the 40-acre tracts or on 30-ft. offsets from the section and quarter-section lines. Levels were run over the lines thus established, and subsequently a satisfactory grade line was laid out.

3. The ridge-line method was used where it was found impossible to make deliveries from a land-line location. This is the simplest method of locating ditches, and consists merely in determining the high ground of the ridge and following it down with the best alignment possible. Profile levels were then run and a satisfactory grade line established.

A full location party consisted of eight men—a locating engineer, a transitman, a levelman, a rodman, two chainmen, a stakeman and a flagman. Often a smaller party was used to advantage. In about ten months' fieldwork 53.2 mi. of laterals were located and about 21 mi. additional were surveyed in the course of the investigation work.

The foregoing information is taken largely from the office records of the Grand Valley Project at Grand Junction, Colo.

Shooting Out Tunnel Heading Under 150 Ft. of Water

What is thought to be the first instance of blowing out the final rock heading between a completed hydraulic tunnel (lined and fitted with control gates) and the body of water which it tapped, so that the tunnel immediately went into service, was reported when on Feb. 14 the face of the Alaska Gastineau Mining Co.'s Annex Creek tunnell was blown out into Annex Lake. Great interest attaches to the work, since the depth of water on the face was about 150 ft.

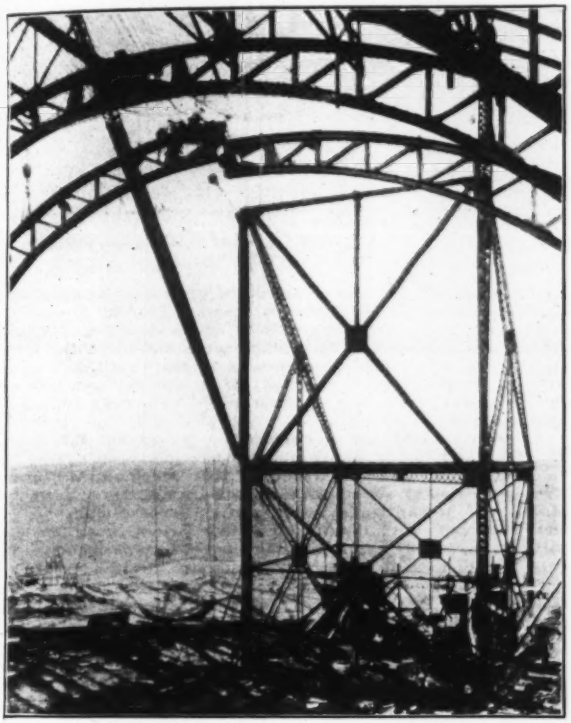
Several months before the final work, diamond-drill holes had measured the thickness of rock to the lake. The face was carried to within 5 ft. of the water, and a pocket was cut on each side of the tunnel. From these pockets final measuring holes were driven top and bottom, using regular machine drills (Sullivan water type) working through a valved nipple. Then 84 holes were drilled 8 in. apart in the face, with machine drills working to within 12 in. of the water. A few holes were very wet so that only 75 were loaded. About 750 lb. of 40% blasting gelatin was used. The temperature ranged about 20° below zero, but the gelatin did not freeze. Fire clay was used for tamping—expensive material, but the only clay available. Waterproof caps were not kept in stock so that electric fuses were waterproofed by dipping in sealing compound, taping and coating with paraffin paint. Each cap was tested before going in and the circuit was later tested (by galvanometer).

A bulkhead was built up of fine muck about 50 ft. back of the heading where the tunnel made a turn. A second similar barrier was placed about 300 ft. farther down. Then the outlet gates were closed and water was turned in from the outside. The tunnel was 1,400 ft. long, 7 ft. high and run on a 1% grade, so that when the portal was covered the water extended back only 700 ft. The water was allowed to rise until it reached the bulkhead nearest the portal—about 1,050 ft. in. The shot was fired with a No. 5 blasting machine. A pressure gage on the water in the tunnel registered only 10 lb. rise, although the concussion shook the snow off the trees for several hundred feet around. The waste and head gates were then opened and the tunnel allowed to clear. Then water was turned into the power pipe line. The work was done under H. L. Wallenberg, Chief Engineer, and J. A. Wilcox, Assistant Chief Engineer of the company.

Erecting Steel Arch Trusses

The erection of the steel-frame buildings on the new Municipal Pier at Chicago included the placing of large arched trusses for the main hall of the recreation building. This hall is 140x150 ft., and is to be used for public concerts and other entertainments. The pier and its superstructure were described in *Engineering News*, July 29, 1915.

The main framing of the great hall consists of three-hinged steel arch trusses having a span of 136 ft. 8 in. c. to c. of shoe pins and a rise of 74 ft. 4 in. from shoe



ERECTING ARCH TRUSSES FOR THE RECREATION HALL ON THE CHICAGO MUNICIPAL PIER

pins to crown pin. There are four of these trusses, spaced 20 ft. c. to c., connected by longitudinal girders and purlins. The end of the hall is semicircular, and has ten half-trusses placed radially. These have the two panels omitted and their heads are attached to a semicircular ring girder carried by the last of the full-arch trusses. To relieve the pressure upon this girder, the backs of the radial trusses have cantilever framing on the lower portion, which supports a part of the superstructure and thus acts as a counterweight to the half arch.

The chords are pairs of channels braced together and having cover-plates on the lower portions. The web members are built up of angles. The hinge pins are 4 in. for the shoes and 3½ in. for the crown. Above the trusses is a monitor roof.

For the erection, a steel-frame traveler was used, mounted on wood rollers on two runways about 36 ft. apart. The traveler consisted of a rectangular tower 38½ ft. square and 32 ft. high (or 37½ ft. above the ground), carrying at the top of its forward frame the two 40 ft. masts with back braces to the rear frame. Each mast had a 90-ft. latticed boom. The masts were connected by a top strut and bracing, as shown. The traveler carried two hoisting engines, one with three drums and the other with two drums. Its weight complete was 50 tons, and the hoisting capacity for each boom was 10 tons.

The steel was sent by freight on the Baltimore & Ohio R.R. to 12th St., where it was unloaded by a gantry yard crane and hauled by team to the site. The largest member handled weighed about 3½ tons (the crown segment of the arch) and was about 6½ ft. and 38 ft. long.

The arches were assembled complete on the ground, well bolted up, in two segments. Each segment, forming a half arch, was raised by one boom. The chain was attached at about 37 ft. from the head of the truss, the weight of this overhanging portion being about 3½ tons. The two booms were operated simultaneously and raised the two segments until the top ends came into position. The crown pin was then driven. The lower ends of the segments rested on the cast-steel shoes while the lifting was being done, so that each boom was holding only part of the weight of the segment it was lifting. The weight of the half arch was 10 tons, and each radial arch weighed 9 tons. The first full arch was first erected, and then the traveler worked backward to the outer end of the pier.

The total amount of steel placed was about 1,150 tons, and this was erected in the period from Aug. 15 to Oct. 15, 1915, with an erecting force which averaged about 40 men. No shop painting was done, but two coats of red lead were applied in the field.

An interesting feature of the work was the use of manila nets to protect the erectors. These were 12x40 ft., attached to the steel framing below points at which the men were at work. This use of protective nets, as required by the State Factory Inspection Department, was noted in *Engineering News*, Mar. 2, 1916.

The steel framework was built and erected by the Morava Construction Co., of Chicago. The pier and buildings were designed and built under the direction of the Harbor and Subway Commission: E. C. Shankland, Chairman, and W. L. Artingstall, Harbor Engineer.

NOTES

Pulling Up Stumps and Trees with Gasoline Tractors is practiced extensively in the Southern States. With old stumps whose deep roots have rotted, a direct pull by the engine may suffice; but if the cable is led over a pulley on top of a tripod, it gives a lifting effect that helps to pull out the roots. The same effect is given by what is called a "dutchman." This is a strong fence post about 5 ft. long, driven into the ground at an angle of about 30°, with its upper end over the stump. The chain or cable wrapped around the stump is led over a notch in the top of this post and thence to the tractor. The strain on the cable tends to raise the post, and the leverage thus gives a vertical lift. For large green stumps the tractor may be used to operate a stump-pulling device.

Water-Tight Sewer Construction is practically impossible in quicksand, water-bearing sand or soft muck under ordinary conditions and with the usual materials, according to a paper read before the Iowa Engineering Society by Charles P. Chase, of Clinton, Iowa. If the cement is covered, the water bores it out; if it is left to harden before covering, the weight of the shifting sand or the movement of the pipe cracks the joint open. In a job in wet sand Mr. Chase had good results by using a 1:1 cement-mortar (made as stiff as it could be worked) on top of well-calked oakum joints and then plastering the joint with a waterproof putty-like blue clay found on the job. To overcome the objections to cement, he has used sulphur compounds, tar compounds and asphalt, but